"The Nation that controls margins will rule the Universe!"

APA- TECH 71

The Eleventh Anniversary Issue

G.T. Buckfast + Shalmaneser

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The minimum level of activity required is six pages per year, not including frankings; up to two covers a year will be accepted as "minac."

The copy count for the APA is twenty (20).

The deadline for APA- TECH 72 is Saturday, 11 August 1990.

Valli & Joa and Roxanne should send in some money soon.

Your postal account, before this was sent on its way, contained two unmatched buttons, a stale gumdrop, and:

$20.53

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Ah, it feels good to be able to breathe again! Things are getting caught up on now and the APA will be back on schedule next month. In the meantime, here are some more fun things to read and contemplate...

We are, as always, actively recruiting members and would like to bring back contributors who were with us in the past. Presently, the schedule is still bimonthly, the annual dues are $2 a year, and the copy count is twenty. Since this **is** our anniversary (the Eleventh!), I would like to entertain suggestions from all of you concerning anything at all about the APA. We've made it through a number of times of instability, but we're still hanging on OK. But we've been doing things in certain ways for a long time and some changes could be helpful. Please think about this a little while you're enjoying your summer. Oh yeah, we can **always** use covers... Have fun!!

Shal.

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Prelude to a vacation

Being one of the (all too often occasional) contributions of
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As I write this, I'm watching 2001: a space odyssey. It's interesting to note how undated large parts of the film appear today. The opening sequences at the dawn of man look a little shabby today, something about the layout of the sets to incorporate the flat front projection screens at the back. Also, the masks that the actors wear when playing primitive man look too dry and matte, somehow. But the rest of the film doesn't seem dated at all. Well, all right. Some things do seem a little incongruous. For example, on the moonbus, we have a visual landing display that looks ok, although a little simple, and the hand controller the pilot uses would look at home on a modern jet (or, for that matter, in a modern video arcade), the nixie tube[1] numeric displays are a little out of place.)

By the way, HAL's birthday is coming up. He became active at the HAL plant in Urbana, Illinois on January 12, 1992. (Hail to thee, Alma Mater!) I've never forgiven Peter Hyams and Arthur C. Clarke for putting Dr. Chandra on the faculty of the University of Chicago in 2010! What was wrong with good old University of Illinois? (Then again, maybe the scandal over HALs behavior was great enough that he was kicked off the faculty and had to take a position somewhere else.)

1. The nixie tube was an early numeric display, consisting of a vacuum tube which had wire cathodes shaped like the numbers zero through nine inside it. As they couldn't all exist at the same depth inside the tube, they were stacked, and the number (when viewed from anything other than head on) would move towards or away from the viewer as it changed.

Mailing comments on APA-Tech 69

Bonnie – Happy belated birthday. I'm now thirty-one, and I've been waiting for whatever is supposed to happen when one grows up for quite a while now. Then again, maybe it happened and I didn't notice. After all, I can't trust myself anymore, I'm over thirty.

I've been known to call the date of my birth "Fibonacci day", after the famous mathematician. (Any of you that I've already bored with my parlor trick can skip to the next comment.) But not because he was born on that day.

Fibonacci is mostly remembered by high school students for the

"Fibonacci series".

Take two ones: 1, 1.

Add them together to get the next number in the series: 1, 1, 2.

Now keep repeating this, adding the last two numbers in the series to get the next: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, etc.

For my trick, only keep the first six terms in the series: 1, 1, 2, 3, 5, 8.

Take them two at a time, and separate them with slashes: 11/23/58.

That's my birthday.

(Some mathematicians use a "zeroth" term in the series of zero. This yields essentially the same series: 0, 1, 1, 2, 3, 5, 8, ... But as I don't personally know anyone born on 1/12/35, I ignore them as revisionists.)

Valli – Why does the top left of the first page of your 'zine read 60f3E?

"Sex and Batman is feasible, sex as an intimate reason for revealing his identity are not." I'm not certain that I agree. Batman, the movie was clearly aimed at a more mature audience than the comics of my youth, which had the comics code authority and parents to deal with. In the sixties, the comics played with the idea of marrying characters off, but usually never did anything except as imaginary throwaways. The usual excuse given for not marrying anyone off was that the wife (most sixties superheros were male) of the hero would become his Achilles heel. All the villains of the world would compete to kidnap her for use as blackmail. Thus, either he would always have to worry about her or it would make for some very short marriages.

But, upon closer examination, I notice something else interesting about those imaginary stories. Usually, the wife to be was not informed of the husbands dual identity until the honeymoon. (There are counter examples, but this was the rule.) This is unthinkable today! Imagine not telling your betrothed that you have a night job as an axe murderer, before the wedding. It simply isn't done. These days, the theory is that marriage is to be a partnership.

So, while I agree that the revelation of Bruce Wayne's alter ego was a bit precipitate, given that it is an irreversible step. (A saying of Ben Franklin's echoes in my ears: "Three may keep a secret, if two of them are dead.") Perhaps it would have been acceptable if more ground work had been lain in the course of the movie. Then again, frequently movies become outlines of stories due to the inability to acceptably portray characters thoughts, and a need for dramatic pacing that is (thank God) lacking in real life.

Susannah – Be careful! Tetris is addictive. We let it loose at G-Bar, and it only gradually caught on with the options traders, but when it did they got very competitive. I, myself, only score in the ten thousands. The traders found another way to compete, however. In addition to the absolute score, which is made up of several factors[2], Tetris reports the number of lines you've made disappear by filling them completely up. The traders didn't bother with the score (which is saved to a "top ten" list, like in arcade games), but compete to get rid of the largest

2. I've noticed something odd. I used to start on the lowest speed, and play until I "wiped out" at speed nine. Lately, however, I've started on speed seven, with about four rows of random blocks on the bottom. And my scores seem equivalent, either way.

number of lines per game. On a good day I can get 120, which put me in the upper ranks at the office.

On your search for a faith of your own, Bravo! I have always felt that the training in religion that we get as children is a bit *ahem* parochial. It seems to be saying to most children that the parents religion is the only one on earth worth joining. Indeed, it implies that it is the only "true" religion, an attitude that can explain a lot of the bloodier and less sensible periods of history. While most religions today attempt to deal with matters a bit less preemptively (I remember visiting a synagogue with my methodist class. But mostly I remember it because later we had bagels. I'd never had them before, and I liked them), it still seems unfair to give someone directed religious training before, say, late high school. That's the earliest I think I could have started to deal with the issues involved.

(If you think I don't like the idea of my parents deciding what religion I'd be, you're somewhat right. I don't even like the idea that my grandchildren get a say in the matter as well. It seems (as far as I understand it, and given that I haven't really researched it all that well, I welcome corrections) that if any children of mine, or children of children, etc. become Mormons, then any documentable ancestors are converted as well. (There are little things about the Mormon faith that I find odd or vaguely disturbing. Perhaps I'm guilty of a little religious intolerance, in which case I'll accept the nomination, as I'll need all the help I can get...)

Rod – I don't have a phone in my bathroom. Instead, I have an answering machine. I don't see that many reasons to put the comfort of my callers ahead of my own. (I hold that the person on the receiving end of a phone call has most of the privileges, as they are the party being intruded upon without notice. This explains why I totally approve of caller ID service from the phone company. If someone wants to call me, I don't see why they should be anonymous. And if they need to be, they can use a pay phone. There's usually one within a block or two of anywhere you're calling from.)

As for Mach 3 or Mach 6 personal jets, I think you've overlooked the most critical part of the system in evaluating feasibility: the pilot.

Looking at the wash out rate in air force fighter training, and the training flight fatality rate makes me suspect that the necessary skills and quickness of reflexes would limit the market almost before price entered the picture.

Diane – When I was in grade school, I checked out all the books in our school library on magnetism and gravity, convinced (by my schoolmates indifferent reading habits) that no one else had read all of them, and that the secret of anti-gravity must be there to be discovered. I seem to recall that I had difficulty talking the school librarian into letting me check so many books out at once, and a certain amount of trouble dragging the box home that afternoon.

The local libraries I used to frequent (my old work schedule got in the way of library use) used to have 8mm films for check out, then they got into video tapes (what organization didn't? For a while there, you could rent video tapes at almost any gas station, and one local pizza place would rent you a tape to

be delivered with your pizza) and now they've added CDs.

Annette – Going to classes without registering for them was one of my favorite ideas back in college. Of course, the more advanced classes tend to be a bit more intimate, and those teaching them are more likely to notice an unregistered student and complain.

My scholastic history, however, is marred by the fact that I originally got this backwards: I registered for classes and then didn't go. As I survived high school by having a good memory, and grasping concepts quickly when presented to the class, I thought at first this would work in college as well. As most people that have tried it can testify, this doesn't work at that level.

On programming languages, I got my start in BASIC and it did cripple me for a while. (I found out later that some of my attempts to figure out what could be done to improve BASIC had led me to conceive of the basic attributes of structured languages.) While Edsgar Dijkstra can proclaim that "It is practically impossible to teach good programming to students that have had a prior exposure to BASIC; as potential programmers they are mentally mutilated beyond hope of regeneration."[3], the rest of us have to remain a good deal more practical. Besides, he penned these words in 1975. Since then, most implementations of BASIC have evolved the capabilities for structured programming. I think Pascal is a better first language, but that is only because it hews more solidly to the modern conventions.

If you don't mind a little kibitzing from someone who doesn't know what level you're teaching the course at, doesn't know what you intend to cover (and probably doesn't realize that you've already finished that project), I've always thought that some of the problems in A. K. Dewdney's "Computer Recreations" column in **Scientific American** would make good class problems. There was also some books teaching Pascal, set as mysteries solved by Sherlock Holmes, with the aid of Babbage's analytical engine. Then again, I don't know how well non-conventional material goes over in the classroom. I have the feeling that when some students are presented with any deviation in the classroom environment, they lock up and can't function. (This is just an off the cuff theory. Anyone have anything to support it?)

On the matter of how we treat people in general, and how we treat those that don't fit our stereotypes in specific, I'm going to duck writing any comments at this time, as I'm preparing this manuscript at the last moment. I will remark that I've recently come to the difficult realization that I treat my family differently than I do my friends. (In fact, I treat the members of my family worse than I treat my friends. Sad, but true. I might try to make excuses for it in how they act towards me, but that is simply rationalizing.) On the social problems in GT, I find that a lot of the early thoughts that occurred to me in response were, just as you said, lame excuses. A lot of times when I introduce people or events into the conversation and newcomers are around, I try to include a (all too)

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3. Dijkstra, Edsgar. "How Do We Tell Truths that Might Hurt," *Selected Writings on Computing: A Personal Perspective* Springer–Verlag, 1982.

brief capsule summary as to what that was all about, in hopes that they will then look back and find the anecdote interesting. But that probably doesn't work.

IT'S BACK!

Being a financial trading firm, the company I work for has a terminal hooked to a service that stores the last thirty days worth of news stories that might be of interest to the financial market. Back when the cold fusion story broke, the first I heard of it was in the Wall Street Journal. (In fact, that was the first that a lot of scientists heard about it, too, which was one of the things that seemed wrong about the whole thing.) Anyway, all further reports concerning it appeared in the nuclear fuels industry news index. (As it was having an effect on the price of Palladium, it also sometimes cropped up in the precious metals index.)

Well, it seems that a researcher in Utah who has been trying to replicate Fleischmann and Pons' original experiment has published his findings in the British journal Nature. Fleischmann and Pons have responded, not with a letter to the journals editors seeking to set the record straight, but with a lawsuit demanding that the paper be retracted. Is anyone really sure these guys majored in chemistry, or could it have been political science?

Heinlein

Go to your book shelf, and get down your Heinlein. (Most of you have a fair amount, if not all of his works.) Is any of it looking worn? Did you like the way it was written? If you answered yes to both of these questions, you may want to run down to the local book store and buy a new copy now, as before too long you may not be able to. Oh, it's not going to go out of print just yet, quite, but it's going to be...different.

It seems that the literary estate of Robert Heinlein is going to be restoring certain of his books to the form they were in when he wrote them.

Not too bad, perhaps, but I can't help but have my fears. I dearly like some of Heinlein's works (Have Spacesuit, Will Travel, Citizen of the Galaxy, The Moon is a Harsh Mistress stand out in my mind), but I tend to feel that the quality declined towards the end. Most people blame this on whatever disease it was that he was suffering from, but I suspect the true culprit was fame.

When an author gets to be a really major name, it gets tougher for an editor to change things. The author tends to get their own way, instead. Perhaps too much so.

A friend of mine tried an experiment. He took one of the trade paperback copies of The Number of the Beast, and edited it. He bracketed parts of the text, blacked out occasional sentences, and put a large black metal binder clip on an entire section of the book, thereby effectively rendering it nonexistent. He then gave the book to another person that had read Heinlein, but not this particular book. She liked it, and found it readable. Imagine my shock. (I had purchased the slightly more expensive British hardcover edition right after the book was released, having been given to understand that the American edition was to be slightly shorter. Sigh. Indeed it was.)

At any rate, certain works of Heinlein are going to be reprinted in a slightly longer edition, with more of his original text UnEdited.

Grumbles from the grave - a review of sorts

At one point in his life, Robert Heinlein proposed to write a volume of autobiography and letters, to be published posthumously. He never wrote it, alas, but his letters have been edited by his wife and are now released in hard cover under his proposed title, Grumbles from the grave.

If these are grumbles, then Mr. Heinlein must have been possessed of a particularly mild disposition, which I believe we can infer is not the case.

Most of the letters in this volume are from Mr. Heinlein to his agent. Too large a proportion, in fact.

In his letters, as his popularity grew, Heinlein complains about the press and volume of correspondence. Yet, little of this is reflected in this volume. As the letters here represented business, and Mr. Heinlein had formed a policy of responding to unsolicited correspondence on postcards, perhaps they are all that has been retained in the files. However, I was informed by Alex Eisenstein that there was some correspondence included in some papers Heinlein donated to a university somewhere. It was originally sealed, as it concerned a lawsuit involving a film script for an unauthorized film that appeared to be an adaptation of Red Planet. Nothing whatsoever concerning this appears in the book.

Another complaint I have is the books organization. There is an attempt to organize the notes by topic. As I progressed in reading the book, i reached the letters that do not directly concern themselves with any of Heinlein's books. Frequently, I found myself paging back to place the letters in context. There were vague references to work being done, and lack of time, but later in the book, few explanatory notes as to the reasons.

I realize that the book had to be organized somehow, and I have no idea if chronological is as common as, say, topic, or person addressed. I haven't read enough volumes of collected letters.

I bought this book looking for an insight into the thought processes and work methods of Robert Heinlein, one of the giants of this field of literature. I do feel somewhat better informed now, but there is much not given. The first mention of Heinlein's first wife reads, "". Virginia Heinlein never mentions her by name. Her name only appears in an excerpt of one of the letters. There is a mention of a bomb shelter Heinlein finished in his home in Colorado Springs. (How he could have hoped that any shelter would protect him when he was so close to a central command point is a bit mysterious to me. Perhaps I'm not accurately judging the power of the weapons of the time, or perhaps I'm overestimating the weapons effects likely from such an attack. Or perhaps I'm simply reacting with a fatalism more typical in my generation than in the time of 1964.)

However, It is generally readable. I wish there was some sort of time line in the back of the book, but you can usually follow what is going on. It does stand alone, as no other work that I'm aware of has had access to Heinlein's papers. I could perhaps wish it was more voluminous, or that it had been prepared by someone more detached from the personalities involved. But that book, if indeed it can ever be written, will have to wait, perhaps until after those involved are dead. (It is not uncommon for people donating their papers to universities to seal parts of them for a specified time interval or until all the people involved are safely deceased.

A few movie reviews

The hours I work have had the effect of severely limited my social life of late, and as I've usually tended to view going

to the movies as a social function, this has put a crimp in the number of recent releases I've managed to see.

However, I purchased a VCR a year or so ago, and someone has finally opened a video rental place within driving distance of where I live that almost keeps my hours, so I'm starting to get caught up. Here are a couple of mini-reviews of recent (and not so recent) movies:

Leviathan: A review

There were three big underwater movies this year: *Deepstar Six*, *Leviathan*, and *The Abyss*. I didn't manage to see *The Abyss* in the theaters, in spite of several attempts. (I did rent the tape when it finally came out.)

Various reports had stated that *Leviathan* was the second best of the three, with *Deepstar Six* a distant third.

Now, I've been interested in underseas technology since high school, and have followed the design career of Ron Cobb with great interest. So, when I learned that *Leviathan* had some design work by Cobb (who designed the human part of *Alien*, and *The Abyss*) and that it was already out on tape at my local rental place, I decided to give it a try.

If this was second best of last years undersea films, with the third far behind, all I can say is that the third film probably constitutes biologically hazardous material.

The movie starts out promisingly enough, but soon after degenerates into a disappointingly direct ripoff of *ALIEN*. In spite of a setup that could have led to a plot twist with some compassion and a stunning indictment of the corporate mentality, we're left with a plot containing a needlessly stupid monster, and too many predictable attempts to surprise the audience with sudden endangerment of a crew seconds from safety. I liked Peter Weller in *Buckaroo Banzai* and *RoboCop*, but in this film, he comes off rather wooden. His characters best moment in this film is one where he is, in fact, not on camera.

All the important elements of the plot are telegraphed (or perhaps I should say, billboarded, so blatant are they) to the audience well in advance of anything happening in the movie.

All the actors seem at least familiar, with Peter Weller and Richard Crenna being the most recognizable. I think one actress was best known for an ad on TV, in which she asked you not to hate her for her hair.

The plot gimmick that gives rise to the monster in the film is telegraphed by a joke told by a character long before anyone on screen realizes what is going on.

Exactly who is going to get it, and in which order is similarly given away, and the final suspense scene...isn't.

In all honesty, I can't recommend this movie, as horror or action. This is a cheap movie, that tries to play some of the emotional games that filmmakers like Steven Spielberg pull off so well, but this one just can't make it work.

Die Hard

My reaction to this movie surprised me. I'd seen the trailers for it shown before other movies I'd gone to see, and they showed some interesting action sequences, but that alone is usually not enough to interest me in a movie. Also, I'd not gotten the best impression of Bruce Willis' dramatic skills. I ran out of time for television a few years ago, and had never seen much of *Moonlighting*, which (other than some bad reviews noted in passing) constituted all I could recall of his career.

So, I'm no longer quite certain why I checked out this movie.

But I can recommend it, with some

caveats.

1. The movie does have a lot of violence in it, some of it a bit graphic.

2. There is a lot of strong language in it, as well.

But if you can stand for that, go rent it.

The story is a somewhat kitschy anti-terrorist romp. Yes, that sounds like a strange way to put it, but it is! By the end of the movie not only will you feel involved in the fate of this character, you will find that you've had a good time. (Put down the strait jacket, I have NOT gone psychotic.)

The plot is well paced, and the surprise reversals usually are just that...surprises. It shows one man surviving in a complex environment against a determined group of international terrorists, in spite of bureaucratic waffling by the various government departments involved.

The Abyss

Now this was a good movie. Three bubbles, as Mr. Higgins puts it. (With an Idiot plot, as he told me, but still, a good movie.)

The underwater technology was believable and well designed. Perhaps the unique way that the film was made contributes to this. (For those that are unaware of it, the movie was filmed in the unfinished containment structure of a nuclear power plant, under fifty feet of water. The underwater scenes and equipment look good because they are what they look like.)

There were surprises, and action. Perhaps the rather drastic view of the government and military (represented by a paranoid navy SEAL) went a bit too far, but the groundwork is lain for him to found not responsible for his actions.

I do wish that there had been a way to show the audience how the underwater habitat was laid out. I found it hard to visualize how various scenes connected with others, physically.

And I must confess that I really didn't like the ending, but you can't have everything.

But where else can you see demolition derby played with manned submersibles?

Virus Notes

In a (not too) recent 'zine, I mentioned that the Chicago Tribune had attributed the Columbus Day computer virus to someone who thought that it was unfair for Columbus to get all the credit for the new world when there were so many competing claims, and feared that the politization of computer crime would continue.

Well, it did. Reports have reached me that someone (also apparently from Europe) spread a worm through SPAN (NASA's Space Physics Analysis Network) that created a sign on message ranting against the Plutonium based radioisotope thermal generators aboard Galileo. (Isn't it a shame we don't have to apply numbers to space probes to tell them apart anymore?

Closing notes

So, that closes this out. Or, almost.

It's been about two months since I returned from my train trip out west, and I'm still not settled back in.

I've recently realized that I know the code I've written so well I can test changes and discard bad ones while in the shower, fourteen hours after I'd last been at my machine.

In short, it's time to wander.

So, I've quit my current job and am off on a jaunt out west, camping. I'd originally hoped for a few months, but I've been forced to settle for a few weeks, due to financial constraints.

Be seeing you.

Follow the Yellow Brick Geodesic

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I'm writing this on my Amiga using the Excellence! word-processing software I bought about two years ago. I'm finally getting around to reading the manual (you know, the kind that comes in a four-inch thick loose-leaf binder in a slipcase), so I am learning how to use this as I go along and will probably incorporate additional features into this text as I find out about other capabilities.

I'm gradually getting back to leading something more nearly like a "normal" life. I've finished the last of my formal course requirements for Astronomy this past quarter and will probably only be taking one course a quarter next year for my own interest. I had my written preliminary examination in astrophysics on May 18th and passed it, so I can go on to the next obstacle. I am casting about for a thesis advisor this summer. I have ideas on the kind of project I'd like to work on, but I have to bring it into line with things that someone here is also interested in. By next May, I have to take my oral preliminary exam, which involves getting up and explaining what I'll be working on, why anyone should bother, how I'm going to approach it, and then try to answer anything at all the faculty may care to ask. I'd like to get that out of the way sooner, so I'm going to try to be ready early next year. In the meantime, I have a couple of little jobs I'm involved with that I'll talk about in more detail next time (like when there *is* something to talk about...).

We had the neighborhood re-landscaped for free last Sunday morning. About 5 AM, the severe thunderstorm we were warned about the previous night came through with something like hurricane-force gusts. Hundred-year-old trees were downed all over the area, taking power lines, lampposts and parked cars with them. (Somehow, I managed to sleep through all this...) I was fortunate in that I was only without power for about nine hours; some people had to get along without for more like sixty hours. The weather here has been pretty strange all along, anyway. Spring was extremely rainy, putting an end to a three-year drought. We are about 50% ahead on precipitation so far this year.

Things have been pretty wretched here for the last few months, so I am only now getting caught up on a lot of things that had to be left to languish. I also had to pass up a number of opportunities to hear people I will probably never get a chance to cross paths with again. **Clyde Tombaugh**, the astronomer who discovered Pluto sixty years ago this past March, gave a lecture in April sponsored by our Department. I was an usher for it, but couldn't stay for his talk, as I had a prior commitment to give a tour of our old telescope on campus (and was stood up...). I embarrassed myself somewhat by asking a party of four elderly people for

their tickets and discovering that one of them was our speaker! (Well, I hadn't seen a *recent* photo of him... Tombaugh is in his eighties now.) **John Kenneth Galbraith** was invited to give a lecture, which was held right in the Physics building; unfortunately, it was at the same time as our weekly astronomy colloquium. **Nicholas Slonimsky**, a noted musicologist and a very entertaining speaker, I understand, made his appearance during my afternoon class; since he's already 96, I figure I've probably missed my lifetime's chance to hear him. And, of course, **Mikhail Gorbachev** blew through town for an afternoon as I was getting ready for finals. It's been a pretty eventful spring, I guess... It's nice to live in a city where lots of interesting people come to call and exciting things are happening and I'm looking forward to getting to some of them.

(After complaining about missing all of those people, I should mention that **Benoit Mandelbrot** was just here to talk a bit about fractals and to show us the results of a collaboration with the American composer Charles Wuorinen. A presentation was made recently at the Guggenheim Museum in which slides of all sorts of fractal images were shown, set against a performance of Wuorinen's "New York Notes." One of the interesting aspects of the music is that it included the use of computer-directed production of 1/f "noise" by four synthesizers generating musical phrases at different tempi.)

* * *

I've received some letters over the past few months from some of the folks I used to work with at General Dynamics. Our first commercial Atlas-I launch was supposed to be in June to launch the Combined Radiation and Release Experiment Satellite (CRRES). The satellite is to travel on a fairly long, eccentric orbit to monitor the Van Allen radiation belts and to release various easily-ionized elements that will act as tracers in the magnetic field. The information is of scientific interest, but the results are actually being used to estimate effects on proposed SDI spacecraft. They were making preparations to launch when a high-pressure line in the Centaur upper stage let go, started flailing around, and smacked the interstage adapter, which supports the upper stage on top of the Atlas booster, making a few holes and dents in it. Not quite as bad as the time a couple years ago when one of our (former?) workers forgot to disconnect a line from the Centaur while it was under pressure, withdrew the work platform, tore the steel skin of the tank, and popped the Centaur like a balloon — then the satellite it was holding up fell in on the wreckage... The mission I was working on during my last year out there, the Eutelsat-II communications satellite, is now scheduled for next February on an Atlas-II (originally planned for 21 March 1989 until the client postponed things). In January, we're supposed to send a DSCS (pronounced "discus"; I forget what *all* the initials stand for, but it's a DoD communications satellite) on our first Atlas-II. Next June, we launch one of a series of new GOES weather satellites. It looks like we've also landed a contract to launch a Japanese communications satellite to go on 30 April 1991, assumed the spacecraft is ready in time, to say nothing of us... Meanwhile, the Advanced Launch System program is just about shut down (if no one can

afford SDI, there's no point in rushing the design of a new heavy-lift rocket...). The Moon and Mars mission studies probably aren't doing much now, either, since the money is about to vanish and there's no time pressure to prepare for such missions. Who can say how Congress will feel next year?

I made a bet with myself about a year or so ago that the Shuttle would just reach mission #40 by its tenth anniversary on 12 April 1991. With two orbiters down with plumbing leaks right now on the way to getting ready for launch #35, it appears that my money is quite safe. There are two questions I'd like to ask at this point. The first is whether the Shuttle will *have* a twentieth anniversary. My feeling is that it will not as such: there will either be a second-generation system in use by then or that we will have abandoned "reusable" rockets at that time. I'm expecting an announcement *circa* 1997 that the STS program will be suspended. The Space Station will not figure into it too greatly, since it will be quite far behind schedule by then (*don't* expect it to be in use before 2001) and the method of launch may be re-evaluated by then (especially if they decide to redesign it completely by then...). [This is all speculation on my part, but I am very pessimistic about the direction things are headed and the availability of adequate funding for the next fifteen years.] The other question I have it what NASA will do if we lose another orbiter. I think it will be *extremely* difficult to get another $2 billion-plus to build a sixth orbiter and that there will be a lengthy investigation into the type of space program this country needs and whether the Shuttle program belongs in it. My belief is that the loss of another orbiter will kill the program; people are *not* looking at it as the development of an experimental vehicle and it is *still* not being treated as such. (What's your view? We'd like to know...) The current Shuttle problems and the recent embarrassment of the Space Telescope optics error is starting to sour the public on expensive, "unnecessary" projects. I think things are going to run pretty cold for big space efforts for the next ten years (the Russians seem to be taking the same attitude as well).

* * *

I will take this opportunity to congratulate Barry Gehm and Jo Anselm on their recent wedding. I regret that I was unable to attend it, but this situation up here has been fairly desperate. (I probably don't need to elaborate on the obligations of graduate students.)

I am going to have to make this shorter than I intended once again, owing to considerations of time. I am about to leave town for a couple weeks. I will be going to Boston first to attend the first East Coast meeting of the Astronomical Society of the Pacific, their 102nd annual meeting. There is a symposium on the "Formation and Evolution of Star Clusters" that I am interested in hearing, since it may have some relevance to my work later on. I also haven't visited Boston in about six years. Then I will be visiting with my folks in New Jersey for about a week-and-a-half. After that, it's back to work...

I ought to describe the frankings this time. I am chairman for the Space Sciences and Astronomy sessions at the AIAA Aerospace Sciences

Meeting in Reno this coming January. This mostly entailed my hounding people by phone to make sure they were getting their individual sessions put together. We will be running paper sessions on the environment of the Space Station, on the NASA Space Grants program (how you can get Gummint money to think hard about doing stuff in space), and on computer simulation of fluid dynamical phenomena in astrophysics (the largest number of sessions are run by the Fluid Mechanics people, who like to come to find out what other people do to compute the behavior of complicated fluid flow and to look at the pretty movies). We also have Dr. Peter Stockman, one of the deputy directors of the Space Telescope Science Institute, coming to talk about Hubble. I was in Chicago briefly at the end of June (thanks to Bill H. for putting me up) for a meeting to schedule the 127 sessions into the four days of the meeting. Some people were concerned as to whether this was still an appropriate talk; we decided that it may be *quite* timely in January and that they should still be able to get some interesting scientific results out of the instruments, even if the focusing is blurred. (I also ran into one of the Crystal Palace folks I knew from GD, who tells me that my old department is now up to sixty people and is *still* hurting; anyone looking for a job?)

After I saw Bill's article on Hermann Oberth, I learned that Oberth had died late last year at the age of 95. His obituary appeared in the April issue of *Spaceflight*.

I, too, seem to be on many strange mailing lists. I got a letter from a press that publishes agricultural books one day and thought "Oh, I bet they think I'm an *agronomer*." Nooo, they were announcing a book about starting a farm on the Moon!

I continue to receive the *Mars Underground News*, even though that group is pretty high-profile these days (although they may be back scheming in the basement cafes after the FY1991 budget...). I had to pass up the Case for Mars IV conference in June in Boulder; wonder how that went? The Planetary Society has also started offering *Bioastronomy News* to its members. This is actually getting to be a serious topic, too: there was a conference somewhere on bioastronomy (SETI, exobiology, etc.) in June.

Guy and Dan's Big Book of the Sky has made the Book Club! I've copied the offering from Astronomy Book Club (June 1990, if I remember correctly), along with the review that appeared in Sky and Telescope recently. They got a very fine approval from no less than **Chet Raymo**, who has written some popular books on stargazing himself. I also got another review from Mr. Higgins, which appeared in the *Lunar and Planetary Institute Bulletin*. Kids, I think you're a hit!

Finally, I've included a review of the new Philip K. Dick biography and an article from *Mercury* on the early life and career of Edwin Hubble. Find out why a boy from the Midwest grew up to become one of the most famous American astronomers of this century and got a big, blurry telescope named after him...

That'll have to be it for now -- here's the bottom of the page rushing up to meet me. I will trying getting caught up on mailing comments next time. Be seeing you in a month. Take care.

Call for Papers

the Astronautics Laboratory for non-air breathing propulsion. Send abstracts to:

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(408) 742-6355

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AIAA 29th Aerospace Sciences Meeting and Exhibit

January 7-10, 1991

Bally's Grand Hotel

Reno, Nevada

Abstract Deadline: May 14, 1990

The Aerospace Sciences Meeting is the largest of all AIAA technical conferences and one of the preeminent technical gatherings within the entire spectrum of aerospace activities. The multidisciplinary character of the Aerospace Sciences Meeting provides an ideal forum for scientists and engineers from industry, government, and universities to disseminate and share scientific knowledge and research results.

The 29th Aerospace Sciences Meeting will place renewed emphasis on fundamental science issues. Participation by the basic research community is especially encouraged. The meeting will also feature both invited and contributed presentations, addressing future scientific and technical challenges facing the aerospace industry.

Technical papers are presented by authors chosen via: 1) a competitive selection process based on peer review, as described below and 2) invitation of papers of highest quality to emphasize major trends and accomplishments in various aerospace disciplines. To facilitate simultaneous sessions, papers will begin on the hour and half-hour. Six papers per session are planned, but session organizers are encouraged to include one-hour survey papers where appropriate.

The technical committees sponsoring this meeting, areas in which papers are solicited, and the names and addresses of meeting organizers to whom abstracts are to be sent are listed below. Every effort will be made to provide uniformly rigorous evaluations and acceptance rates for all sessions.

Rules for Abstract/Manuscript Submission

Abstracts are to be submitted in accordance with the following general rules:

1. An abstract of at least 1,000 words is required in triplicate and is to be sent to the appropriate meeting organizer. Please include title of the paper, author(s) name, title, company, complete address and telephone number.

2. Authors are to complete and submit abstracts in accordance with the "Abstract Submittal Form" found on page B48. Please note that the title and author's names submitted on this form will be those used in the preliminary meeting program. **Please check, where indicated on the form, whether video playback equipment (1/2" VHS-standard) is needed.**

3. The submission of a draft of the paper in addition to the abstract is encouraged. If a draft manuscript cannot be submitted by the due date, an extended abstract is strongly encouraged. The extended abstract should include key figures that illustrate the primary intent of the author's message. Dummy figures are acceptable if final data is not available, provided that final data will be submitted with the completed manuscript. The review and acceptance process will be weighed in favor of those authors submitting more relevant documentation of their proposed paper.

4. The abstract **may not be submitted to more than one meeting organizer.** Authors may request that a copy of the abstract be forwarded to a specific additional organizer. If this option is selected, please provide an additional copy of the abstract. Failure to comply with this rule can result in rejection of the paper.

5. The deadline for submission of abstracts to the meeting organizers listed below is a postmark of **May 14, 1990.** Early submission allows more time for review and would be greatly appreciated by the meeting organizers and reviewers. Letters of acceptance will be mailed on or about **August 2, 1990,** and final manuscripts are due at AIAA Headquarters on **November 1, 1990.**

6. A general "no paper-no podium" policy will be in effect for contributed and invited papers. This policy means that an author will not be allowed to speak if a written paper has not been prepared and preprints are not available to attendees at the meeting. Exceptions may be made at the discretion of each technical committee.

Space Sciences and Astronomy

Papers are solicited from topics in space science and astronomy. Papers describing scientific results from recent missions, concepts for new science missions and payloads, and in-depth reviews are encouraged. Although all submissions related to topics in space research will be considered, specific sessions at this year's conference will focus on:

1. Research aimed at characterizing the interaction of Space Station Freedom with the space enviornment, including the effects of radiation, debris, ionized plasma, and charging.

2. Computational fluid dynamics and magnetohydrodynamic simulations in astrophysics.

3. Planning for scientific experiments, technology demonstrations, and policy innovations associated with President Bush's Human Exploration Initiative in the space program.

Send abstracts/manuscripts and Abstract Submittal Form to:

Gregory J. Ruffa
Dept. of Astonomy
Univ. of Minnesota
116 Church St. SE
Minneapolis, MN 55455
(612) 379-9622
(612) 624-0211 (msg)

OBITUARY

Professor Hermann Oberth

We greatly regret to record the death of Professor Hermann Oberth, one of the major pioneers of space flight.

So great were his pioneering achievements in the field of rocket research that the Society, at its meeting on 12 February 1949, unanimously agreed to invite Professor Oberth to become its first Honorary Fellow.

Professor Oberth was born on 25 June 1894, at Hermannstadt, in Transylvania, and began his scientific studies at Munich in 1913. He fought in the 1914-18 war and was wounded in 1915, after which he became an ambulance sergeant at a military hospital in Schassburg, Transylvania, where he remained until the end of the war. This gave him the opportunity to resume his interrupted studies and to take up his astronautical investigations: at this time he also explored the psychological effects of weightlessness (see *Wege zur Raumschiffahrt*, p. 102 et seq). From the end of the war until 1923 he continued his studies at the Universities of Klausenburg, Munich, Gottingen and Heidelberg, obtaining the diploma of professor at Mediash in Roumania in 1923. After leaving he studied medicine, physics and astronomy, in the same year, his *Die Rakete zu den Planetenraumen* was published by R. Oldenbourg in Munich, better known to many under the title of the third (1929) edition of *Wege zur Raumschiffahrt*. Rynin mentions that a Russian translation of the 2nd edition also appeared.

Hermann Oberth (centre) with officials of the Army Ballistic Missile Agency at Huntsville, Alabama in 1956. (Left to right) Dr Ernst Stuhblinger (seated), Major General H.N. Toftoy, Commanding Officer, 'Project Paperclip', Wernher von Braun and Dr Robert Lusser. Stublinger is a Fellow of the Society and received the BIS Bronze Medal. Wernher von Braun was both an Honorary Fellow of the Society and received the BIS Gold Medal.

He began his teaching career at Schassburg, moving to the high school at Mediasch in 1926, where he remained until 1938. During 1928-31 he was on leave for research and stayed mainly in Berlin, when he worked on the technical side of the UFA film "*Frau im Mond*", made in 1929. In that year he was awarded the first REP-Hirsch Prize and also conducted his first experiments with liquid air. One of his assistants at that time was Wernher von Braun, later technical director at Peenemunde. *Wege zur Raumschiffahrt* was written during this period. The first section was concerned with the theory of rocket flight, and follows the usual course in considering the equations of motion, air resistance,etc. Oberth also dealt with the calculation of exhaust velocity, orbits of a rocket in free flight, step-rockets, the use of airships for launching rockets at a great height and reasons for using alcohol rockets at low altitudes and hydrogen rockets at greater heights. The second section is a detailed account of a design for a two-step rocket 5 metres long (excluding fins). The first step would use alcohol and liquid oxygen as propellants and would entirely enclose the second step, propelled by hydrogen and oxygen. The total height reached would be 1,960 km, and the time of flight from launching to return to the Earth's surface would take 35 min. Section three considers the physical and physiological effects of abnormal gravity, a design for a passenger rocket, Oberth's comments on Goddard's work and his reply to criticisms of his work voiced after the publication of the first edition. Oberth's article in the collective work *Die Moglichkeiten der Weltraumfahrt* (1928), is briefly mentioned; it gave some constructional details for a rocket to be fired to a height of 50km.

Oberth's work at Berlin showed him the great importance of practical engineering experience and, for a while, he left his theoretical study to concentrate on machine design and similar matters. From 1933, in addition to his main work, he was in charge of a training school for mechanics.

In 1938 he was appointed professor at the Technische Hochschule in Vienna to carry out secret experimental research work. Two years later he was transferred to Dresden to direct a section designing fuel pumps for the future V2. In 1941 he went to Peenemunde, where his work consisted of examining ideas and projects from other fields which might be of value to rocket technology. He also made calculations in connection with step and long-range rockets. Professor Oberth also prepared a report on large, guided AA rockets employing solid fuels as propellant.

In December, 1943, he went to the Reinsdorf factory of the Westphalisch-Anhaltische Sprengstoff AG (WASAG) to develop these rockets. Considerable technical problems were encountered and overcome, and Professor Oberth believed that rockets of this type had considerable possibilities, both for military purposes and as lower steps for space-ships and long-range rockets.

After the war he was detained for four months in a camp with the engaging name of "Dustbin" and, when released, went to live at Feucht, near Nuremburg where he had purchased a house and some land in 1943.
He lived there with his family since 1945, and until retirement, cultivating his farms and undertaking advisory scientific work. A museum at Feucht contains many Memorabilia and similar items commemorating his work.

Lunar Base Agriculture: Soils for Plant Growth. D.W. Ming and D.L. Henninger, editors. Published by the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America. Hardcover, 255 pages, 1989. ISBN 0-89118-100-8. Price: $24.00 (members' first copy $20.00).

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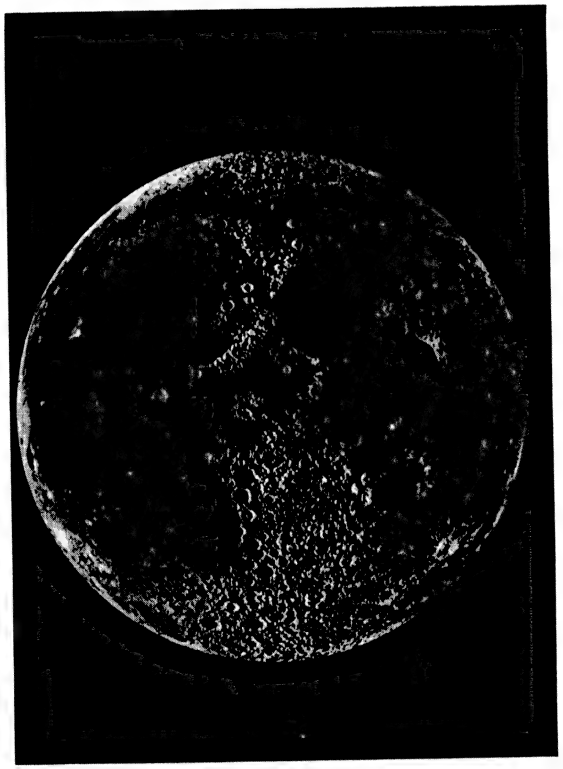


LUNAR BASE AGRICULTURE

SOILS FOR PLANT GROWTH

Lunar Base Agriculture: Soils for Plant Growth

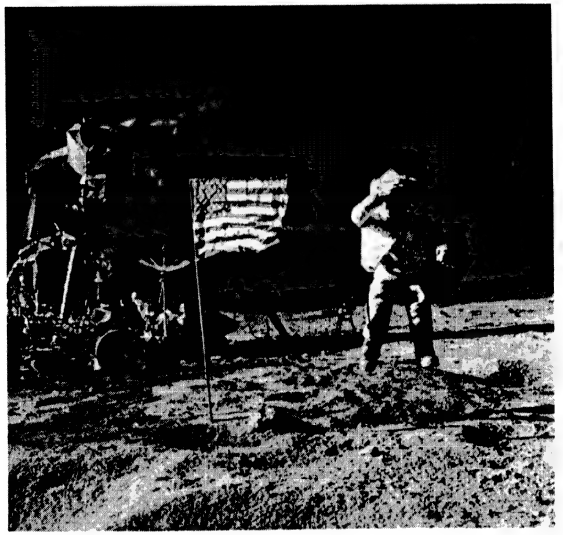
The National Aeronautics and Space Administration is considering the possibility of creating human presence on a permanent basis beyond Earth. Initially, selected missions are being evaluated as case studies, including (i) the human exploration of Mars and its satellites, Phobos and Deimos, (ii) the establishment of a lunar science outpost, and (iii) the evolutionary expansion of humans into our inner solar system. The first step will probably be the establishment of a lunar base.

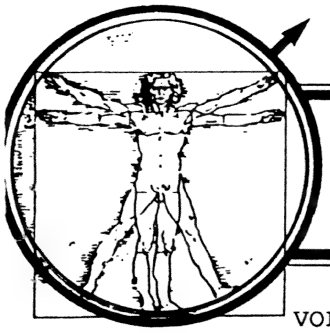
Some reasons to return to the Moon have been suggested, including (i) scientific research, (ii) utilization of lunar resources, and (iii) attainment of self-sufficiency in the lunar environment as a first step in planetary exploration. Food production at a lunar base is a primary concern. Lunar materials will indeed play an important role in the development of lunar base agriculture.

Lunar Base Agriculture: Soils for Plant Growth is a collection of papers by scientists from different disciplines who are interested in the future of agriculture at a lunar base. Over 70 specialists attended a NASA-sponsored workshop where the primary goal was to identify a course of research dealing with the interaction of lunar resources and agricultural systems. This publication addresses the goal and contains sections on (i) lunar base scenarios, (ii) the lunar environment, (iii) chemical and physical considerations for a lunar-derived soil, (iv) biological considerations for a lunar-derived soil, (v) current research in controlled ecological life support systems, and (vi) future research needs for plant growth at a lunar base.

Whether or not plants will be grown on the Moon has not been answered; however, it is a possible scenario that will continue to be discussed by the planetary community. This publication will serve as an information source for those individuals seeking ways to produce food in space—particularly if the Moon serves as an outpost to launch human exploration to our inner solar system.

The chapters and authors include:





Mars Underground News

VOLUME III, NUMBER 1 WINTER/SPRING 1990

MARS OVERVIEW MEETING HELD IN BOULDER

The following summarizes the conclusions drawn at a February meeting of the Mars Underground, held in Boulder to prepare for the Case for Mars IV conference. It was contributed by C. P. McKay.

The fundamental rationale for the human exploration of Mars was the topic addressed at the Mars Overview meeting held 16 February 1990 in Boulder, Colorado. Over 40 participants from a wide range of technical, educational and policy areas attended, including representatives from the international space community.

A key conclusion from the group was that, in light of the rapidly changing world scene, a complete reassessment of the role of human space exploration is essential.

The National Space Council, under the chairmanship of Vice President Quayle, has asked for new ideas from the space community, including sources within and outside of governmental agencies. The group offered the results of this meeting as one contribution to this gathering of new, stimulating ideas.

The consensus that the Mars Overview meeting reached points to the need to develop a strong set of fundamental rationales for human exploration of Mars. The group identified five major categories of motivation. They are

1. Social: The social motivations for exploring Mars include basic biological, sociological and psychological drives to explore and to expand, and to develop new-found opportunities for human betterment. The result of these activities will invariably advance human knowledge, opportunity and world view. Outside of the Earth, Mars is the most hospitable planet in the solar system, with all of the resources needed to establish a future home for life. The exploration of Mars captures the imagination and pioneering spirit in America; it focuses human energy in an epic endeavor; and it promotes national pride and prestige.

2. Scientific: Mars is the planet which will yield a rich harvest of scientific information about planetary evolution, climate change, and the origin and evolution of life in its planetary cradle. Its study provides an assessment of Mars as a future habitat for humans and a second home for life in our solar system. Critically, in this time of endangered global environment, it also provides a second viewpoint for understanding Earth and its precious biosphere.

3. Educational: This critical rationale responds to the national emergency in education, particularly in technical fields. Mars as a national space goal will inspire students of all ages to appreciate science and technology as a positive force in society, and it will provide an optimistic view of everyone's

role in the future. It elicits the best talents and capabilities of all students and stimulates initiatives for re-education and renewal in the workforce while providing opportunities for future employment and other expressions of those talents.

The vision of Mars as a national endeavor gives new purpose to education; it becomes a vehicle for promoting scientific and technical literacy throughout society; and it establishes a national identity that will stimulate the flowering of generations of technically competent participants for future long-term space exploration.

4. Economic: The exploration of Mars has immediate benefits for the U.S. economy. A large segment of our economy has historically been based on national defense. In addition, the United States has a leadership role and a positive balance of trade in the aerospace sector. To protect this investment in a changing geopolitical climate, a strong commitment to a civilian space program is in the national interest. It provides a channel for maintaining the national technical capabilities and a constructive focus for human enterprise.

Mars is a territory of inestimable value with abundant resources, a hospitable environment and an auspicious location. Mars has the potential to support thriving human settlements and to become a hub of commerce situated at the gateway to the asteroid belt and the outer solar system.

5. International: Human Mars exploration opens a rich avenue for friendly diplomatic interaction with the Soviet Union, the European Space Agency, Japan and any other spacefaring nations that may develop. It provides a natural leadership role for the United States in world affairs.

These elements set the framework for the upcoming Case for Mars IV conference to be held in Boulder, Colorado, June 4-8, 1990. Sessions will be devoted to each of these major areas of human interest in Mars exploration. The other major goals of the conference are to review Mars scientific objectives and program activities worldwide, and to present innovative program concepts and technologies that will increase the feasibility of Mars missions. In addition, workshops will address the development of a baseline architecture for Mars exploration and strategies to meet the educational challenge of the space exploration era.

BUSH ADMINISTRATION PLANS TALKS ON INTERNATIONAL SPACE VENTURES

The daunting challenge of establishing a lunar base and sending humans to Mars has encouraged the Bush administration to plan talks with the Soviet Union, Japan, Canada and the European Space Agency (ESA) on cooperation in space.

The administration announced this "exploratory dialogue" in a March 30 release. The National Space Council has been directed to determine the feasibility of international cooperation and to set guidelines for the talks.

Response to the announcement ranged from tepid to enthusiastic. ESA is cautious in light of their strained relationship with NASA over the space station program. The Soviet Union has many times called for cooperation with other spacefaring nations in the exploration of Mars.

JPL TESTS SEMI-AUTONOMOUS NAVIGATION TECHNIQUES FOR MARS ROVER DEVELOPMENT

JPL has begun tests of semi-autonomous navigation techniques using a six-wheeled vehicle configuration that might prove useful in Mars exploration. The experiments are primarily to evaluate navigation software, not vehicle design.

The navigation involves having stereo cameras aboard the rover make 3D maps of the terrain ahead of it. The rover's computers then plot the safest course and execute it without further visual reference. It repeats the process in 5 to 8 meter (16 to 26 foot) segments, which take about one hour to traverse. Most of the time is spent in plotting the course, not in travel.

Mars rovers will have to travel up and down inclines, cover rocky ground and avoid getting stuck in dust-traps. A successful rover should be able to take care of itself, for a radio signal from controllers on Earth would take between 4 and 22 minutes to reach the rover (depending on the Earth-to-Mars distance). By the time they had warned it to avoid

a dust-trap, the rover could have already fallen in.

With improved microprocessors now under development, the test rover should be able to reach speeds of three centimeters per second (one inch per second). On an actual Mars mission, this would translate into a range extending about 100 kilometers (60 miles) from the landing site.

MARS ROVER SURVIVES CLOSE CALL--FOR NOW

Last January Mars mission supporters were faced with a bleak prospect: It appeared that NASA would be forced by budget cuts to stop or slow down many advanced Mars mission studies.

Congressional actions to meet Gramm-Rudman-Hollings cutbacks, among other restrictions, forced the space agency to cut back some programs. The advanced planetary program was hit especially hard.

Fortunately, support was found within the Space Exploration Initiative (SEI) at NASA to supplement the advanced planetary program studies as they relate to SEI. Some of the activities of the former Mars Rover/Sample Return (MRSR) development program (Site Reconnaissance Orbiters, Rovers and Sample Return systems) are now being studied as elements of the robotic precursor portion of SEI. This work is now being funded through a Johnson Space Center (JSC) program under the Office of Exploration (Code Z). (Code Z has since been reorganized into the Office of Aeronautics and Exploration Technology, Code R.)

After 15 years of maintaining that MRSR is the next major step in Mars exploration, and after assigning it first priority after *Mars Observer* (set to launch in 1992), NASA has changed its strategic plans.

The Global Network Mission has replaced MRSR as the first priority mission. The network would consist of as many as 24 simple surface stations arrayed around the planet and carrying instruments to measure meteorological, atmospheric and surface properties.

Rovers, once proposed for a 1984 mission, have been relegated to a fifth-

ROBOTIC MISSION SET

from the plans of NASA's Space Exploration Initiative 90-Day Study

MISSION	LAUNCH DATE	SCIENCE	SITE SELECTION	ENGINEERING
MARS OBSERVER	1992	ATMOSPHERE, GLOBAL SURFACE	GLOBAL SURFACE	SURFACE COMPOSITION, ATMOSPHERE
LUNAR OBSERVER	1996	GLOBAL SURFACE	GLOBAL SURFACE	SURFACE COMPOSITION, TOPOGRAPHY
GLOBAL NETWORK	1998	WEATHER, SEISMOLOGY, GROUND TRUTH	GROUND TRUTH, IMAGERY	SURFACE PROPERTIES
SAMPLE RETURN	2001	EVOLUTION, HISTORY, SEARCH FOR LIFE	SURFACE PROPERTIES	END-TO-END MISSION, TOXICITY
SITE RECONNAISSANCE ORBITER	2003	REGIONAL MAPPING	SITE MAPPING	TOPOGRAPHY, ROVER TRAVERSE PLANNING
ROVERS	2007, 2011, 2015, 2017, 2021	SURFACE PROPERTIES, EVOLUTION, HISTORY, SEARCH FOR LIFE	SITE CERTIFICATION	SITE CERTIFICATION

generation post-*Viking* mission to launch in 2007. How this will fare with the National Academy of Sciences and other space science advisory committees that have long supported Mars Rover/Sample Return remains to be seen.

JSC planners give priority to sample return missions over rovers because such missions can be early tests for human exploration of Mars.

Although NASA has cited cost as a major reason for revising its plans, it has offered no quantitative description of the Mars Global Network or other options.

The JSC-led Mars studies that are to support President Bush's Space Exploration Initiative include robotic precursors and human mission requirements. NASA has organized four implementation groups: Planetary Surface Systems at JSC, Space Transportation at the Marshall Space Flight Center, Robotic Missions at JPL, and Transportation Nodes at the Langley Research Center. JSC and JPL are analyzing the Mars Sample Return mission for 2001 as part of the robotic mission set of the SEI. -- *Louis D. Friedman*

FRENCH SPACE AGENCY AWARDS MARS BALLOON CONTRACT TO THE PLANETARY SOCIETY

The Centre National d'Études Spatiales (CNES) has given The Planetary Society a $125,000 contract to continue development of the guide-rope for the Mars Balloon. The balloon probe, to be built by CNES, is scheduled to fly on the Soviet *Mars '94* mission.

Under the provisions of the contract, the Society has sent Jim Cantrell of Utah State University to the CNES facility in Toulouse, France to help integrate the "Snake" guide-rope design into the total balloon package.

The Mars Balloon is part of an ambitious mission that will include an orbiter, small landed stations and, perhaps, several surface penetrators. As is their custom, the Soviets will launch two identical spacecraft on the mission.

The balloon is designed to fly during the day when sunlight warms the atmospheric gases within it; at night when the gases cool, the balloon will sink toward the surface. A portion of the balloon will be filled with helium to keep it from reaching the surface.

The guide-rope will touch the ground, stabilizing the balloon during the night. It is designed to be dragged behind the balloon, taking surface measurements as it goes. The innovative Snake design (so named because it resembles a snake as it is dragged along) enables an instrumented payload to be in contact with the surface without snagging.

The Planetary Society has supported Snake design work for three years, working with teams from JPL, Caltech, Titan Systems, Inc and Utah State University. The work has progressed under the direction of CNES, the Soviet Institute for Space Research and Glavkosmos' Babakin Center. Funds have been provided by Society members and a small grant from the Sloan Foundation.

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BIOASTRONOMY: THE SEARCH FOR EXTRATERRESTRIAL LIFE

BIOASTRONOMY NEWS

VOL. 3, NO. 1 PUBLISHED BY THE PLANETARY SOCIETY JANUARY 1990

NEWS BRIEFS

META II SOON TO SCAN SOUTHERN SKIES FROM ARGENTINA

The Planetary Society's SETI program, using the multichannel spectrum analyzer called META (megachannel extraterrestrial assay), will soon expand to the southern skies when META II goes online at the Argentine Institute of Radio-Astronomy. Juan Carlos Olalde and Enrique Hurrel are now at Harvard University with Paul Horowitz, designer of META, building the equipment and learning how to operate it.

META I, the most extensive and advanced SETI effort in the world, has been operating continuously since September 1985 at the Oak Ridge Observatory in Massachusetts. But because of its northern latitude, META I cannot see a significant portion of the galactic plane. When META II is installed in 1990 at the Argentine Institute of Radio-Astronomy headed by Raul Colomb, we will reach complete sky coverage, and simultaneously observe the large equatorial region visible to both observatories.

Meanwhile, META is now carrying out a meridian transit from declination -30° to +60° using sensitive GaAsFET receivers connected to an 8.4 million channel receiver. The receiver is sensitive to narrowband carriers in its received bandpass of 400kHz, which we set to bracket a guessable (or "magic") frequency such as the 21-cm emission line of neutral hydrogen. We circumvent the problem of doppler shifts (caused by relative motion of sender and receiver) by further assuming that the transmitting civilization has adjusted their transmitter to compensate for their planetary motion. Thus we are seeking guessable frequencies in guessable reference frames: the local standard of rest, the galactic barycenter or the cosmic blackbody rest frame.

META was built with a grant from Steven Spielberg, matched by donations from Society members. Further information can be found in *Icarus* **67**(1986), and *The Planetary Report,* Jan/Feb 1986, and July/Aug, 1987.

OHIO STATE SEARCH TRIES NEW APPROACH

The Ohio State University SETI program, the world's oldest continuing radio search for artificial extraterrestrial radio signals, is preparing a new strategy based on advances in computer technology, according to Dr. Robert Dixon, the project director.

For over 12 years the Ohio State telescope has been scanning for signals in the traditional way: routinely searching through the entire sky, later going back to examine interesting things. The problem with this approach, says Dixon, is "when you go back, the interesting things are never there."

This was the case with the famous "Wow" signal, where the telescope picked up some sort of radio signal that never repeated, and so could not be verified. (In the margin of the printout, next to the signal, someone wrote "Wow"; hence the name.)

With equipment advances, the Ohio State telescope is now able to track an object for one or two hours, while a computer monitors its progress. "When the computer thinks it's found something," Dixon says, "it can zoom in and investigate it immediately." This new program is called SETI Zoom.

Parts of the program are up and running now and, according to Dixon, the entire system should be operational in a few months.

NASA SETI PROGRAM CAUGHT IN BUDGET QUAGMIRE

When it finally gets under way, NASA's SETI program will be Earth's most powerful radio search for alien life. But first it must negotiate the ponderous yet capricious budget process of the United States government. This year's request for $6.8 million will probably be trimmed back to $4 million, in a continuing pattern of underfunding.

The program has frequently been targeted for cuts by lawmakers seeking to reduce the federal deficit. For Fiscal Year 1989, NASA asked for $6.1 million for SETI, and received only $2.2 million. This pattern of underfunding has delayed hardware development and, if it continues, could threaten the program's chances of success. The longer we wait, the more congested Earth's radio environment will become, until it could become too noisy to do SETI from the surface of our planet.

NASA has mapped out a two-pronged strategy for its search: The "targeted search" will investigate 800 stars similar to our Sun within 80 light years of Earth, scanning around the frequency of the "water hole." The "sky survey" will scan the entire heavens over a much wider range of radio frequencies. This strategy was planned to take six years, beginning on October 12, 1992—the 500th anniversary of Columbus' discovery of the New World.

If this year's budget cut is the last, and future funding requests are granted, then the program can recover and meet its 1992 deadline, according to John Billingham, the program's manager. But if the budget-cutting pattern continues, NASA's SETI program "will suffer some delays," Billingham warns.

Meanwhile, Billingham reports that prototype development is "coming along well" and with full funding can meet its target date. The final systems definition contract will be let during FY 1990.

BACKGROUND BRIEFING

EXTRATERRESTRIAL LIFE
Ideas from Antiquity to the Scientific Era

The idea that life and advanced civilizations might exist in other parts of the universe, a concept often referred to as "the plurality of worlds," appeared many

centuries ago. Around 400 BC, in his treatise *On Nature,* the Greek philosopher Metrodorus of Chios wrote: "It seems unreasonable, in a large field, to have only one shaft of wheat and in the infinite universe only one living world."

Around 50 BC, the Roman poet-philosopher Lucretius stated in *De Rerum Natura:* "Nothing in the universe is unique and alone, and therefore in other regions there must be other earths inhabited by different tribes of men and breeds of beasts." Similar thoughts were expressed in the 13th century by the Chinese scholar Teng Mu, who said: "Upon one tree there are many fruits, and in one kingdom there are many people. How unreasonable it would be to suppose that besides the earth and the sky we can see, there are not other earths and skies in the universe."

The concept of the plurality of worlds has been debated through the centuries, sometimes hotly. The Italian monk Giordano Bruno was burned at the stake for his heretical beliefs, which included the infinity of worlds. However, 90 years later, the Dutch physicist Christiaan Huygens published a very influential work, *Cosmotheros*, in which he attempted to argue scientifically about the habitability of other planets. He also tried to reconcile the Catholic Church with the concept of a plurality of worlds and wrote that "Barren planets, deprived of living creatures, which speak most eloquently of their Divine Architect, are unreasonable, wasteful, and uncharacteristic of God, who has a purpose for everything."

Through the centuries our ideas of how to contact extraterrestrials have reflected the science and technology of the times. In the 2nd century BC, Lucian of Samosata wrote about a voyage to the Moon using a ship with very large sails blown away from Earth by cosmic winds. In the 17th century, Johannes Kepler imagined a trip to the Moon during a lunar eclipse powered by winged demons along Earth's shadow. With the Industrial Revolution of the 19th century we began to have more realistic ideas of how to contact civilizations that might inhabit other parts of our solar system.

The first scientific proposal was made around 1830 by the astronomer and mathematician Carl Friedrich Gauss, who suggested planting in Siberia a 10-mile wide wheat field in the shape of an orthogonal triangle, with squares of pine trees on its three sides, to show extraterrestrials that Earth is inhabited by intelligent beings (or, at least, mathematicians) who know the Pythagorean Theorem. Gauss did not succeed in planting his forest, but he did manage to plant the idea of trying to contact extraterrestrial civilizations.

In 1840, Joseph Johann von Littrow, director of the Vienna Observatory, proposed digging a circular ditch in the Sahara desert, roughly 20 miles in diameter, filling it with water, pouring kerosene on the top, and setting it on fire. To extraterrestrials, the flaming circle--the perfect geometric form--could only be the product of intelligence on Earth. In 1869, Charles Cros of France proposed building a huge mirror on Earth and using it to draw geometric signs on the deserts of Mars by fusing paths on the sand with its focused heat.

Around the same time, a scientist called Schmoll proposed setting up seven large mirrors across Europe in an arrangement similar to the seven stars of the Big Dipper, signaling to extraterrestrials the presence of intelligence (in this case, astronomers) on Earth. The mirrors were to be built in Marseilles, Bordeau, Cherbourg, Amsterdam, Copenhagen, Stockholm and in northern Sweden on the shores of the Gulf of Bothnia. None of these ambitious projects was ever built.

In the middle of the 19th century, Jules Verne imagined a trip to the Moon far more realistic than the one described by Kepler. His rocket was launched from Florida, carried three astronauts, and splashed down in the Pacific on its return to Earth, as happened with the *Apollo 11* mission to the Moon in 1969.

Heinrich Hertz discovered radio waves in 1887, incresasing possibilities for contact with extraterrestrials. In 1899, while working near his home in Colorado Springs, Nicola Tesla received radio disturbances that he thought came from off the planet. He wrote: "The feeling continues to grow on me that I was the first to hear a message of greetings from one planet to another."

In 1922, the Italian scientist Guglielmo Marconi, who in 1901 pioneered transatlantic radio communications, thought he had received radio signals from Mars on his boat *Electra*, which he had equipped with colossal radio antennas. The reason was that these signals were much lower in frequency than those used for wireless communications. He had probably picked up "whistlers," which are natural phenomena produced by low frequency waves traveling along the magnetic field lines of Earth.

Soon the new fields of radio astronomy and space science developed, opening up far more effective means to search for extraterrestrial life and intelligence. We will be discussing these in future issues of the *Bioastronomy News.—Michael Papagiannis*

The Bioastronomy News is published periodically at the editorial offices of The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106, USA for the International Astronomical Union Commission 51.

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Two excellent ways to tour the universe—an introduction to astronomical discovery, and a beginning observer's manual

The Astronomer's Universe

Stars, Galaxies, and Cosmos

By Herbert Friedman

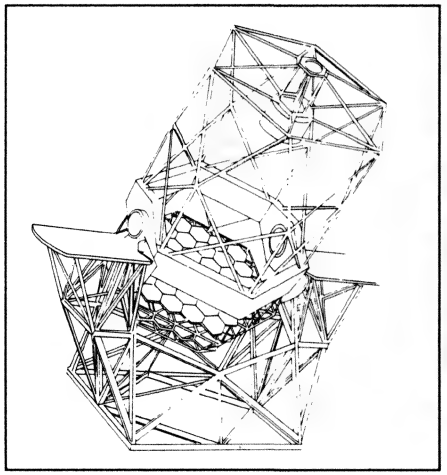
and

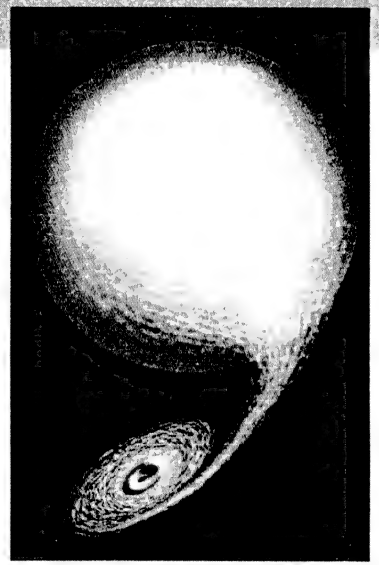
Turn Left at Orion

A Hundred Night Sky Objects to See in a Small Telescope—and How to Find Them

By Guy Consolmagno and Dan M. Davis

Cover: The theoretical structure of a 14-solar mass presupernova on the verge of collapse. **Below:** The 10-meter Keck Telescope, now under construction on Mauna Kea, Hawaii.





Above: Artist's sketch of a blue giant feeding a black hole companion.

Unless one has an in with NASA, exploration of the universe is limited to ground-level study—reading about the theories and history of astronomy, or observing the sky itself. This pair of books helps the beginning astronomer on both counts, first with an accessible introduction to the discovery of various heavenly phenomena, and then with a uniquely helpful, easy-to-use observation manual.

The Astronomer's Universe

In The Astronomer's Universe Dr. Herbert Friedman, who helped usher in the new era of rocket and satellite astronomy, surveys some of the highlights of astronomical progress in the last few hundred years. He first traces optical observation from Tycho Brahe's naked-eye viewings to today's great observatories, the Hubble Space Telescope, and the International Ultraviolet Explorer.

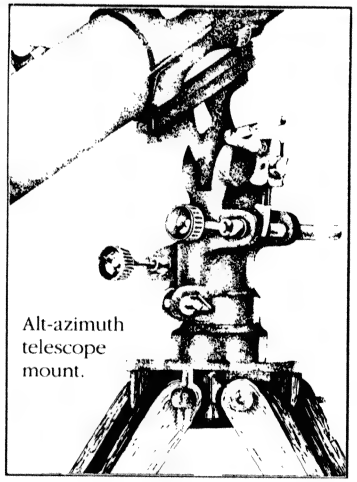
From there Friedman turns to the realm of infrared and other invisible radiation. He explains how radio telescopes can be divided into sections placed far apart, giving the effect of one huge telescope—such as in the Very Large Array, a set of 27 dishlike antennas lined up for miles across the New Mexico desert.

The Astronomer's Universe today, of course, is one of high-energy physics,in which each new discovery seems to provide some answers but even more questions. In a clear manner Friedman explains these innovations, from the discovery of x-rays to gamma-ray astronomy on Earth and in space. He engages the reader in the hunt for the neutrino, and in particular explores why the search for the ghostlike solar neutrino has been disappointing, even though 70 billion of them strike each square centimeter of Earth every second.

Moving to the latest frontiers of astronomy, Friedman explores the emerging study of gravitational waves, which are generated by accelerated masses just as light and radio waves are ripples generated by accelerated electric charges. He describes why some physicists predict gravity-wave astronomy will supplement electromagnetic astronomy in the next decade or two—and what startling discoveries it may provide.

Friedman details the intriguing facts surrounding our Sun: its ferocious burning of two trillion trillion trillion atoms of hydrogen every second; how our middle-aged star will evolve as it ages; phenomena such as solar flares and sunspots; and the search for solar x-rays. He examines the various types of stars, explaining why and how some stars evolve into red giants or white dwarfs, whose densities are measured in tons per cubic inch. And, of course, he explains such fascinating phenomena as novae, supernovae, neutron stars, and the ever-popular black holes.

The lucidly written chapters of The Astronomer's Universe make the dramatic advances in astronomy accessible, whether the book is discussing the connection between pulsars and supernova remnants, the



Alt-azimuth telescope mount.

nature and structure of the Milky Way and other galaxies, theories concerning the expanding universe and the existence of dark matter, or the search for life elsewhere in the universe.

TURN LEFT AT ORION

For serious students of the sky, the various coordinate systems and technical data for locating and measuring celestial objects are indispensable. But what about the observer who doesn't want to confront countless formulas or other mathematical gymnastics?

Guy Consolmagno had the same problem. Wishing to rekindle his childhood interest in stargazing, he sought the advice of his friend, longtime amateur astronomer Dan Davis—who promptly handed him some star atlases and other books. But Guy didn't really learn to understand—and enjoy—the heavens until Dan cut through the technical talk and pointed out some notable celestial sights through a telescope one night. Figuring that others would appreciate an enjoyable, nontechnical guide to small-telescope astronomy, the two friends created TURN LEFT AT ORION.

The book is a model of practicality. All of the objects presented can be seen in a telescope as small as two and a half inches, and the viewer doesn't need crystal-clear skies or even a knowledge of the constellations. To help you find an object, the authors begin each section of seasonal listings with a "Guideposts" section that describes the location of the brightest stars in a given region. From there, they tell how to find the object in question.

In addition, Consolmagno and Davis provide charts showing how an object looks as viewed with the naked eye, through the finderscope, and through the telescope.

Beginning with a tour of the Moon in its various phases, the authors take the reader through the solar system, giving listings of occultations, oppositions, and other notable viewing dates. Without doing a single calculation, the observer can view the phases of Venus... the Martian polar caps... Saturn's rings... and other objects in the universe, such as:

- **The delightful, fascinating "mutual events"** that occur when a faster-moving moon of Jupiter passes a slower one. These take place only once every six years or so, the next time coming in 1990-91.
- **The Trapezium in Orion**, four closely spaced stars in a remarkable area of the sky marked by several lanes of light, separated by darker gaps.
- **The bright galaxies M81 and M82** in Ursa Major, close companions that may be only 100,000 light years apart—20 times closer than the Andromeda galaxy is to our Milky Way.

For each object, the authors succinctly explain what is being viewed, the nature of the object, and how it came into being.

Equipped with a helpful appendix on how to "run" a telescope, TURN LEFT AT ORION is an excellent beginning guide to observing the sky. Because of its easy-to-use format and jargon-free presentation, readers don't have to spend hours puzzling over technical data, and instead can direct their time and energies to observing the heavenly objects.

About the Authors

HERBERT FRIEDMAN is a former director of the Space Science Program at the Naval Research Laboratory.

GUY CONSOLMAGNO teaches at Lafayette College. DAN M. DAVIS is at the State University of New York at Stony Brook.

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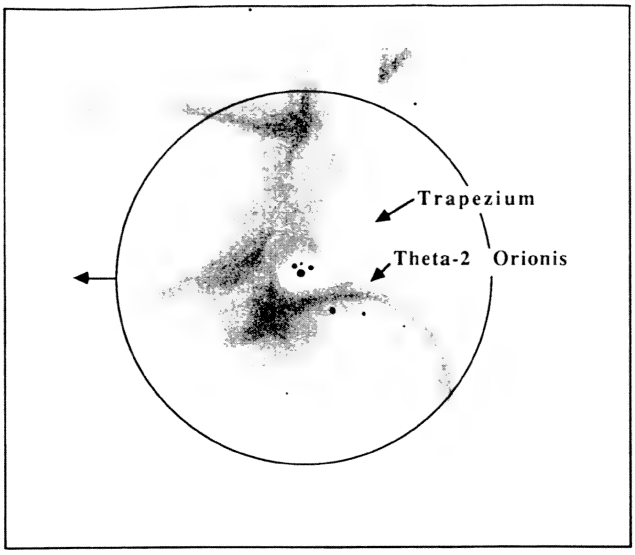
OBSERVING THE CONSTELLATIONS
John Sanford. Simon & Schuster, Inc., New York, 1989. 176 pages. ISBN 0-671-68927-4; $26.95, cloth. ISBN 0-671-68924-X; $16.95, paper.

TURN LEFT AT ORION
Guy Consolmagno and **Dan M. Davis.** Cambridge University Press, 1989. 205 pages. ISBN 0-521-34090-X. $22.95.



This illustration from *Turn Left at Orion* by Guy Consolmagno and Dan Davis zeroes in on the Orion nebula. It is the last of four finder charts for the nebula that progress from a naked-eye view of the constellation Orion to the object's appearance through a small telescope. Of the four bright stars in the Trapezium, all but one are extremely close binaries. They cannot be split in a telescope, but two reveal themselves as eclipsing variables. North is up and east to the right in this telescopic view.

HERE ARE two fine books to join the many new sky guides for amateur astronomers. The maps and photos in John Sanford's book are of a familiar sort, but they have now been brought together handsomely in one package. And Guy Consolmagno and Dan Davis have done something completely novel that will be of great help to beginning small-telescope users.

Observing the Constellations: An A-Z Guide for the Amateur Astronomer seems to have been conceived as a showcase for Sanford's constellation photographs. All 88 constellations are represented by wide-field photos, most of them taken by the author himself. It is difficult to know for whom the selection is intended. One picture will show us stars to magnitude 9 or 10, while another records stars only to magnitude 5 or 6. The scales of the illustrations are neither consistent nor indicated. We are offered no help in recognizing what the photographs show, other than a north-pointing arrow. Advanced observers will be better served by such sources as Hans Vehrenberg's *Atlas of Deep-Sky Splendors,* and beginners will simply be baffled.

Fortunately, the constellation photographs are supplemented by Wil Tirion's star charts of each constellation to 6th magnitude and by file photographs, both by amateurs and professional observatories, of selected deep-sky objects. Beyond this, Sanford's book is a compendium of mythological lore, astronomical history, facts about deep-sky objects, and observing tips. *Observing the Constellations* contains much useful information, most of it readily available in other sources. The book does make up in sleek good looks what it lacks in originality.

Consolmagno and Davis' *Turn Left at Orion: A Hundred Night Sky Objects To See in a Small Telescope — and How To*

Find Them is less colorful but promises to be a valuable companion for the neophyte telescope user. The authors acknowledge the assistance of students from middle school to college level, and the influence shows. The book has the feel of a tool that has been thoroughly tested in the field.

The authors chose the 100 best objects for viewing in a 2- or 3-inch telescope and display each over a two-page spread. Each object is rated like a movie, or restaurant, with telescope symbols: 5 telescopes for M42 in Orion, for example; 4 for the Great Galaxy in Andromeda and the Double Cluster in Perseus; and 1 telescope for the double star Gamma Leonis. The selection of objects and the rankings are purely the authors', but I found little to disagree with. Along with the ratings come tips on required sky conditions and optimum eyepiece power.

Turn Left at Orion is organized by season. A pair of hemispheric sky charts at the beginning of each section gives rough seasonal overviews of the sky looking north and looking south. These bright stars serve as guideposts for the telescope users. Each of the 100 telescopic objects for study gets a naked-eye chart, a finderscope view, and a telescope view at the appropriate power. These unique charts alone are worth the price of the book.

But there is more. The text tells where to look, what to see in the finderscope and in the telescope, and offers observational comments and technical information about what we are looking at and tips on other interesting objects in the celestial neighborhood. Star-hopping, rather than coordinates, leads the observer to an object. The telescope views in the finder charts are mirror-imaged (flopped right for left) to match the view that would be seen through a refractor used with a star diagonal. The balance of technical information and common sense is just right, and the text is pitched at a level that is perfect for the audience.

Here are Consolmagno and Davis on the "double-double" star Epsilon Lyrae: "This pair of doubles is a real challenge, a test of just how sharp your telescope and your eyes are. It's such a challenge, however, that you may not be sure whether you're really seeing the pairs or just imagining them. One way to tell is to have a friend compare observations with you — try to tell if each tiny pair is lined up parallel, or perpendicular, to the line between the two pairs."

The same down-to-earth treatment is provided for all 100 deep-sky objects, and for the Moon and naked-eye planets. The authors resist more than a cursory discussion of Uranus and Neptune, not because those objects are unavailable to the user of a small telescope, but because they have a perfect sense of what their audience wants to see.

I would have liked to see better regional star charts to supplement the rather cartoony seasonal sky views, perhaps centered on familiar guideposts like Orion, Cygnus, and the Big Dipper. But that's a quibble. *Turn Left at Orion* should be packaged with every first telescope. It's as nearly perfect as such a book can be.

CHET RAYMO

A professor of astronomy and physics at Stonehill College in Massachusetts, Raymo has authored several popular books, including Soul of the Night *and* 365 Starry Nights.

COSMOGENESIS: THE GROWTH OF ORDER IN THE UNIVERSE

David Layzer. Oxford University Press, New York, 1990. 322 pages. ISBN 0-19-505528-4. $24.95.

THIS IS NOT in any sense an astronomy book. David Layzer's "cosmos" has the meaning "order" which its Greek original carried, along with the more familiar meaning of "the universe." The author addresses many of the questions that have bothered subsets of philosophers and scientists for generations. How can one make everyday sense out of quantum

By Timothy Brady

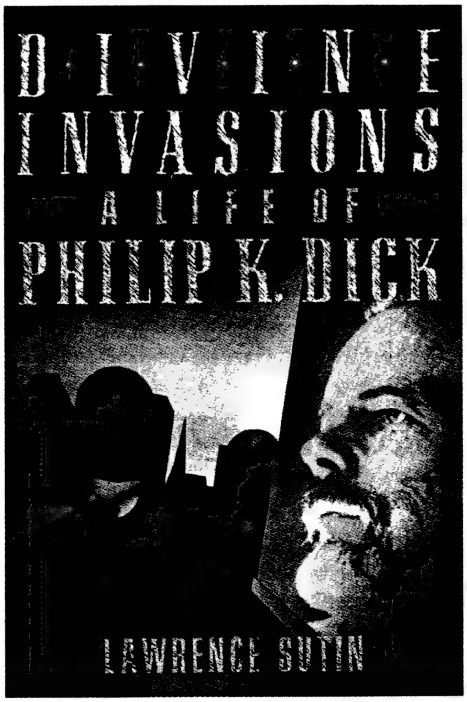
Earth to Phil

Lawrence Sutin examines the life and work of the late Philip K. Dick, a writer with one foot firmly fixed in the outer limits.

DIVINE INVASIONS: A LIFE OF Philip K. Dick (Harmony Books, $25.95) is a likable and informative biography, written by first-time author Lawrence Sutin of Minneapolis. It's a thoroughly researched book that pretty much covers everything you'd ever want to know about Dick's life, from the traumatic loss of his twin sister when they were both infants, through his career and many marriages, to his death eight years ago at the young age of 52. You would be forgiven, however, if one very important question weighed heavily on your mind before you plunked down hard cash for this volume: Who in tarnation is Philip K. Dick?

Unless your taste in literature steers you inexplicably toward those shelves in the library inhabited by characters with names like Zorg from the planet Luxor 6, chances are good that Phil Dick won't appear on your list of great American novelists. Science fiction, the literary landscape Dick trod, is the sort of netherworld that makes even the most dismally self-obsessed mainstream writer feel superior about the way he or she dots an *i* and crosses a *t*. And yet this guy could write.

Dick published more than 50 books during his career, most typed at a pace worthy of Joyce Carol Oates or a graduate of a first-rate secretarial school. Writing was his only source of income throughout his adult life—no academic positions, no inherited millions—so, predictably enough, the quality of his work from stem to stern is a mixed bag, according to Sutin. But if you haven't read *The Three Stigmata of Palmer Eldritch,* to name just one of his better novels, you've been cheating yourself of a ride on a wonderfully weird and intriguing cosmic merry-go-round.



A couple of Dick's best novels, *Do Androids Dream of Electric Sheep?* and *Valis,* achieved some renown as Hollywood movies (*Blade Runner* and *The Man Who Fell to Earth*). And French critics, who like nothing more than to proclaim as gourmet soufflés what we assumed were Cheetos, have for years trumpeted the works of Phil Dick. But by and large, the memory of Dick and his writing has been preserved by family, friends, and a few sci-fi junkies.

Which brings us to the matter of Lawrence Sutin. Imagine yourself a young lawyer with a degree from Harvard Law School, working diligently in the Twin Cities. You have a yen to give up the torts and briefs for a career in writing, but are looking for a subject powerful enough to lure you away from a comfortable salary at the firm to the lesser fortunes to be found in book sales. "If I had engaged in a paper route, I could have made more money," Sutin says of his years working on *Divine Invasions.* Under the circumstances, it might be fair to ask: Why choose as your project a serious biography of a writer renowned only in the ghetto world of science fiction?

"When I first picked up [Dick's] work, I was one of those who thought that science fiction was pretty much trash written for teenage boys," says Sutin, "but I just loved his books. There was an excitement in his stories and a kind of integrity that I think you rarely find in so-called 'mainstream' fiction. I must say, however, that this [determination to quit law and pursue Philip Dick] was the least thought-out decision I've ever made."

Sutin is a native of the Twin Cities who struck out for college in the late 1960s, stopping first at Antioch University in Yellow Springs, Ohio, then spending a year at Hebrew University in Jerusalem before finally getting a double major at the University of Michigan in Ann Arbor in psychology and English (the "two archetypal majors" of his generation). He spent a year working in a bookstore. "I kept looking for people who would come in for soulful talks on rare books," Sutin says. "Instead, they'd come up to the counter with 15 copies of *I'm OK, You're OK.*" After his stint as a bookseller, Sutin says he "panicked and went to law school."

He did his three years at Harvard, graduated in 1976, and returned to the Twin Cities, where he practiced law for about eight years before deciding he wanted to pursue a writing career. Two weeks after quitting his job, Sutin was on a plane to San Fran-

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Timothy Brady writes "Books" regularly for Minnesota Monthly.

cisco, hoping to get a peek at the papers of Philip Dick.

Sutin approached Dick's literary executor, Paul Williams, with "absolutely no writing credentials. There was nothing impressive about me. I was off the plane, looking like one of those rare Phil Dick fans who just wanted to talk about the novels. Williams was very kind. He did indicate to me that it was unlikely that anyone but a very remote university press would ever touch the book."

It is indeed remarkable and ironic that a major publishing house would choose to print *Divine Invasions.* For most of his writing career, Dick's own novels were ignored by the tweedy denizens of the publishing world. He was obliged to sell his books to paperback sci-fi companies like Ace. That a biography of Philip Dick, by a previously unpublished writer, should be accepted at Harmony Books is either a testimony to its quality, a sign of a new appreciation for Dick's work, or dumb luck.

"It even sounds nuts to me now," Sutin says. "But I found an agent [Phil Dick's old agent] who loved the idea, and after about a year of shopping it around in New York, she found an editor who was a Dick fan. He also said that my book proposal was the best he'd ever read. When my agent called and told me that [Harmony] had bought the idea, I just screamed, 'I've got a book! I've got a book!' She said, 'Honey, you don't have a book, you have a contract.'"

To get the book required three years of research, more than 100 interviews, two months of study in the Bay Area and Los Angeles, and "countless" long-distance phone interviews. But his most daunting task, according to Sutin, was poring through the *Exegesis,* Dick's 8,000-page hand-written journal. "My eyes still hurt," Sutin says.

No doubt his mind was strained as well by the chore. Philip Dick was, to say the least, a complex man. The themes of his writing centered around the question, "What is real?" He wrote of worlds trapped within other worlds and time layered upon time. Taxis and other machines might talk in Phil Dick's fiction, and he imagined such things as drugs that could leave a person tripping for an eternity.

Dick lived an oftentimes chaotic life. He was married five times and knew economic security only in the last few years of his life. He was addicted to pills of all sorts, and during the height of the drug culture in the late Sixties he kept a huge jar of assorted capsules in his refrigerator; he would pop them by the handful. It is perhaps not surprising then to learn that the central concern of his fiction—What is real?—was also of great moment in his daily life.

In *Divine Invasions,* Sutin recounts a series of dreams, visions, and revelations that Dick experienced during February and March of 1974. They were of crucial importance in Dick's life and his later writings, and the *Exegesis* is full of references to their meaning. Aside from chatting with God, Dick dreamed he was being tutored in Attic Greek by a scholar from Periclean Athens, and one night he felt compelled to wake his infant son and administer the sacraments of baptism and communion to the little boy.

Sutin treats these strange happenings in the same way that Dick himself viewed them: with both skepticism and respect. The tone of Sutin's book is witty and lacks the stuffiness of excessive analysis. *Divine Invasions* is written with the understanding that what is most important about Philip Dick is that he gave us some marvelous writing:

> Phil always retained the ability to see just how loopy his experiences could seem. Not only could he laugh at them, he could also subject himself to fiercely skeptical questioning.... Phil was neither credulous nor a fool. He held to no single set of beliefs at what was happening to him. Yet he possessed the moral courage to treat it all seriously, as a source of possible knowledge, rather than dismiss it outright.... Phil knew full well just how his experiences would seem to others. Years later, in a letter written before *Valis* was published, Phil predicted the public response to his disclosures. 'Took drugs, saw God. BFD.' Phil never expected to convince others of anything. But he was damned if he was going to deny himself a single avenue of speculation.

Sutin is working on another biography, this one of the English writer Aleister Crowley, a novelist who wrote frequently of the occult. "It seems to be my pattern as a biographer to take a despised genre and find exemplary writers in the field. I like to break down categories."

He does a fine job of it in *Divine Invasions.* ■

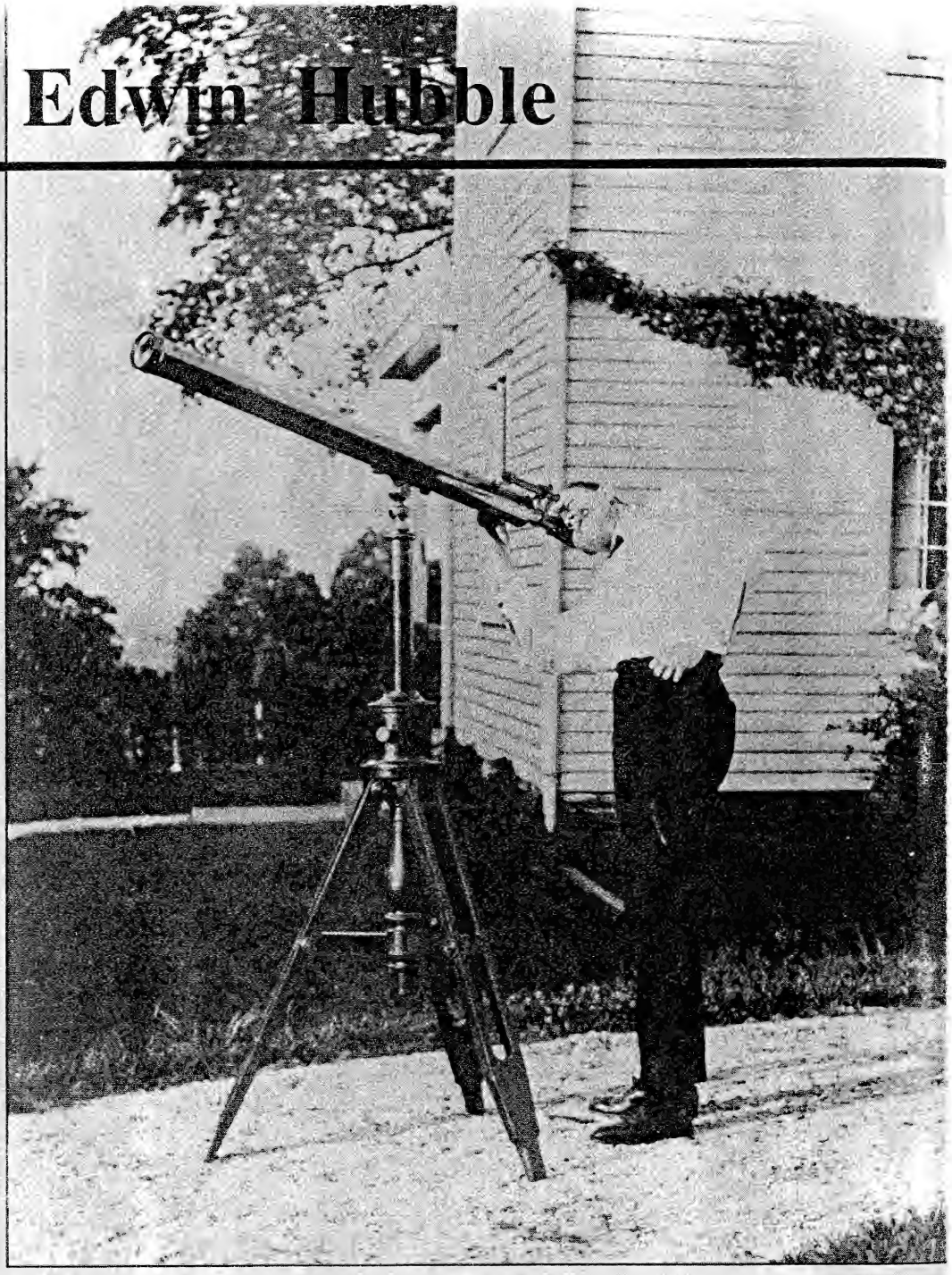
Young Edwin Hubble

Donald Osterbrock
Lick Observatory

Ronald Brashear
Huntington Library

and

Joel Gwinn
University of Louisville



Edwin Hubble "observing" with a small visual telescope, New Albany, Indiana, 1914. (Photograph courtesy of John Hale)

About the Authors:

DONALD E. OSTERBROCK is a research astronomer at Lick Observatory. With John R. Gustafson and W.J. Shiloh Unruh he has recently written *Eye on the Sky: Lick Observatory's First Century*, and he is now working on a scientific biography of George Willis Ritchey (1864 - 1945), the great American telescope maker and designer.

RONALD S. BRASHEAR is assistant curator of modern astronomy at the Huntington Library, San Marino, California. He is currently organizing the Mount Wilson Observatory Archives for deposit there. He is a graduate student at Johns Hopkins University, and is working on his thesis on the early history of infrared astronomy.

JOEL A. GWINN is a professor of physics at the University of Louisville. He is a student of the history of astronomy and has researched in depth the early life of Edwin Hubble, particularly in Louisville and New Albany, Indiana.

Edwin Hubble changed our view of the universe in which we live more than any astronomer since Galileo. Many cosmologists believe that he first observed the high radial velocities of the galaxies, or that he discovered the expansion of the universe. In fact he did not; these discoveries were made by Vesto M. Slipher and Carl Wirtz, respectively. But Hubble's drive, scientific ability, and communication skills enabled him to seize the problem of the whole universe, make it peculiarly his own, contribute more to it than anyone before or since, and become the recognized world expert in the field. He was not only a great scientist, but also a great writer and a great speaker. No one who read one of his books, or heard one of his lectures, describing in simple yet vibrant terms his research and his views on the universe, could ignore him. He had an exciting, compelling personality, far different from most astronomers, much more like those of the movie stars and writers who became his friends and companions in the later years of his life.

Hubble's early life, like those of the stars, or of the hero kings of ancient wars, has become a myth. He has been the subject of fiction, and of supposedly factual biographies which bear little relation to his own real life. This is not strange for he himself, in life, constantly played the hero's role and his wife, who idolized him, after his death glorified him even further. Hubble's official biography was written (for the Biographical Memoirs of the National Academy of Sciences) by his protégé, admirer, and friend, Nicholas U. Mayall, while the great man's widow was still living. There was no reason for Mayall to probe deeply into Hubble's early life; his main task was to tell of his mentor's scientific career, and for the rest he accepted at face value the stories that Hubble had told him and the embellishments that his widow had provided. Why should he go beyond them? She in her turn devoted years of her life to glorifying Hubble in a manuscript biography (now at the Huntington Library) that is demonstrably false in many of its details, and that omits whole areas of his life (and even more of her own). Unfortunately, it has become the inspiration and source for books and articles that purport to tell the story of Edwin Hubble.

There is no question that Hubble's life was an interesting one; his youth and education were peculiarly American. Many contemporary sources of information about his life still exist and we have based our story as much as we can on them, taking from Grace Hubble's account only the parts that ring true in their context, or that can otherwise be verified.

Edwin Powell Hubble (he did not use his middle name ever, nor his middle initial after he could avoid it) was born November 20, 1889, in Marshfield, Missouri. His father, John P. Hubble, was an insurance agent who had been born near Springfield in the same state; his mother, Virginia Lee James Hubble, had been born in Nevada. Both of them could trace their ancestry back through many generations of Southern yeoman families. In Grace Hubble's words:

> His ancestors came from England, Ireland and Wales, with no strains of foreign blood. The first of them to come to America, in the middle of the 17th Century, was an officer of the Royalist Army. In the Revolutionary War and the Civil War they were soldiers; in times of peace, pioneers, living on the land. Tall, well-made, strong, their bodily inheritance had come down to him, even to the clear, smooth skin that tanned in the sun, and the brown hair with a glint of reddish gold. They had handed down their traditions as well, integrity, loyalty as citizens, loyalty to their families... and a sturdy reliance on their own efforts.

The Hubbles had a large family, with seven children who survived. Edwin was the third; his brother Henry and his sister Lucy Lee were older than he, his brother William was the next after him, (each separated by two or three years), while his sisters Helen, Emma Jane, and Elizabeth ranged down to fifteen years younger than he. He started school in Marshfield in 1895. Three years later his father transferred to the Chicago agency of his fire insurance firm and moved his family to nearby Evanston. Two years later they moved to Wheaton, a village west of Chicago, also within commuting distance by train of John Hubble's office in the Loop. Edwin completed grade school in Wheaton.

His seventh grade teacher was Harriet Grote, later, after she married, the mother of Grote Reber, the great pioneer of radio astronomy, who also grew up in Wheaton and erected his first radio telescope there. She recognized Hubble as a "bright boy," and later followed his career with pride and held him up to her son as a model. Hubble's school records are still available for eighth grade, and for his four years of high school, which was in the same "Old Red Castle" in Wheaton as the grade school. They show that in eighth grade his averages in different classes were typically 85 to 90, but that in high school he blossomed. There his grades were nearly all between 90 and 100, and particularly in English, mathematics, sciences (he took chemistry, biology, and physics) and languages (he took four years of Latin and two of German) were mostly all between 95 and 100. He was not the best student in his class, but he was consistently in the top quarter. He could also relax, it appears, for his scores in "application" and "deportment," though quite adequate, were typically lower than were those of the other good students. Throughout high school Hubble was always one of the youngest students in his class, usually about two years younger than the average, and he was only sixteen years old when

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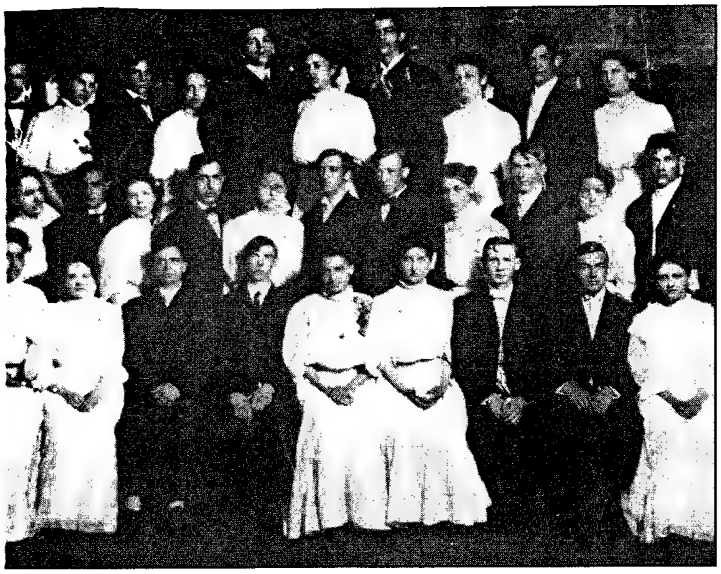


The Wheaton High School Class of 1906. Edwin Hubble is fifth from the left in the back row. (Photograph courtesy of the Mary Lea Shane Archives of Lick Observatory)

he graduated at the end of the winter term in 1906.

Yet Hubble was in no sense a grind. He led a healthy outdoor life, with frequent summer vacations at his grandfather's dairy farm near Marshfield. He was big and strong, not only for his age, but also in comparison with the other boys in his classes, and he became a star athlete for Wheaton High School, especially on its track team. He was a high jumper, broad jumper, shot putter and discus thrower, and ran on the relay team. One of the few surviving clippings from his high-school days shows that as a senior in the spring of 1906 he won the high jump at the Northwestern Interscholastic meet with a leap of 6 feet 1/4 inch.

On graduation Hubble received an academic scholarship to the University of Chicago, which had first gone into operation only fourteen years before. He entered as a sixteen-year-old freshman in September 1906, and again was a good student, particularly in his first two years. In addition to mathematics, chemistry, physics, and astronomy, he took French, Greek, and more Latin. At the end of his sophomore year he received the two-year Associate in Science degree, as was then standard at the University of Chicago, and won a scholarship as the best student in physics to get the degree that year. All of the advanced astronomy courses Hubble took, except for one quarter of observing with a transit telescope and small telescopes, were in analytic mechanics and celestial mechanics, the standard fare in the campus department dominated by Kurt Laves, Forrest R. Moulton, and William D. MacMillan. Hubble's overall work slipped a little, and his average for his last two years was only B-, well over passing, however, and he received his Bachelor of Science degree at the end of March 1910, with enough credits to skip the spring quarter of his senior year.

Again, in spite of the fact that Hubble was two years younger than most of his classmates, he was a very good athlete who won letters in track and basketball. He was tall for the intercollegiate basketball teams of his time (6 feet 3 inches) and very well coordinated, excelling on defense. He could score, too, sometimes making two or four points, sometimes as many as eight or even twelve, as Chicago won by scores like 27 to 2 over Minnesota, 17 to 15 over Illinois, and 28 to 4 over Northwestern. The Maroons won the mythical national intercollegiate championship in Hubble's junior year, and the Big Ten basketball championship in his senior year as well. In track, coached by the famous Amos Alonzo Stagg until spring football practice started, Hubble was a good but not outstanding shot putter and high jumper. He usually placed in the Big Ten dual meets in which Chicago participated, though he seldom won.

Hubble, like most University of Chicago student athletes of his time, belonged to a fraternity. His was Kappa Sigma. On one

Edwin Hubble (fourth player from the left) with the other members of the University of Chicago basketball team, Big Ten Champions, 1910. (Photograph courtesy of Yerkes Observatory, Williams Bay, Wisconsin)

Edwin Hubble, probably on graduation from the University of Chicago, 1910. (Photograph courtesy of Henry E. Huntington Library and Art Gallery, San Marino, California)

occasion in his sophomore year, he and some of his fraternity brothers got into trouble for throwing raw eggs from their windows at passing black-clad divinity students. In his junior year Hubble was one of the appointed university marshals, the student leaders who served as guides at the graduation of the class ahead of them. In his senior year he was elected vice president of his class. In that same year he took the examination for the Rhodes Scholarship. The British-born South African diamond king Cecil Rhodes, in establishing these scholarships, wanted to strengthen the connections between the United States and the United Kingdom, by bringing American students to Oxford University. One scholarship was awarded in each state each year, and Rhodes had specified in his will that each successful candidate should be a manly chap who was a combined good student (but not a "mere bookworm"), athlete, and leader. The Rhodes Scholars were to be between 19 and 25 years old when chosen, and in practice the successful candidates had usually completed their undergraduate degrees in America before they went to Oxford. Hubble was supremely qualified in every way. Six Illinois candidates took the examinations in December 1909; Hubble and one other, a student from Greenville College, passed. The Illinois Rhodes Scholarship Committee, consisting of the presidents of the University of Chicago, the University of Illinois, Northwestern University, and Jacksonville College, was to make the final choice between them. Robert A. Millikan, for whom Hubble had worked as a laboratory assistant in the elementary physics course, wrote a testimonial letter for him. In it Millikan described Hubble as a "man of magnificent physique, admirable scholarship, and worthy and lovable character," and concluded "I have seldom known a man who seemed to be better qualified to meet the conditions imposed by the founder of the Rhodes scholarship than is Mr. Hubble." Not surprisingly, Hubble got the scholarship.

When Hubble "went up" to Oxford in October 1910, he was one of an outstanding group of American students. Some of the other Rhodes Scholars who began with him that year and later became well known public figures were Elmer Davis, a famous reporter and newscaster, Christopher Morley, a prolific author, John Crowe Ransome, a poet and writer, and Robert Hale, a member and speaker of the Maine House of Representatives, and later a United States congressman. At Oxford, Hubble entered Queens College, and "read" (studied) jurisprudence. Both his father and grandfather wanted him to become a lawyer, and he had probably decided to try that career route. At the end of his first year he described his study methods in a letter to his father:

> As you know, I have been studying Law for six months. Real Property and Contracts are now completed and a large slice taken out of Roman Law. The method of study is very different from home. I do not attend lectures for they are mere dictations which we are supposed to take down verbatim. The lectures will not have to be typewritten, so I simply read other men's notes. This permits me to work undisturbed 7:30 or 8:00 to 1:00 at a stretch. That is about all on Law as there are many other things which are worth while. Most of the long afternoon is given to sports. Then tea, then discussions until Hall, which in summer is at 7:30. After Hall there is generally some Club meeting or other gathering to attend or else I read History, Economics &c in my room ... Of c[our]se I haven't done as much studying as I meant to do, but have kept up with what my tutor has planned for me and he says that my work has been very satisfactory.

Edwin Hubble (right) and his brother William, outside the family home, Shelbyville, Kentucky 1910. (Photograph courtesy of Rufus Harrod)

By these methods Hubble completed the Jurisprudence course in the standard two years, and received "second class honors" in 1912. He stayed a third year, beginning the work needed for a bachelor's degree in law, but dropped it and switched to Spanish instead. In Hubble's Rhodes Trust record, the Warden (head scholastic official) wrote "Considerable ability. Manly. Did quite well here. I didn't care v[ery] much for his manner — but he was better than his manner. Will get A." A fellow Rhodes Scholar, Jakob A.O. Larsen of Luther College, Iowa, thought that Hubble in one year had become "very British," aping the language and manners of the Oxford upper crust, and perhaps this is what the Warden meant by "his manner."

As he had written his father, Hubble participated actively in sports at Oxford. At Queen's College he was a star in the high jump and broad jump, and better than most in "putting the weight" (shot put) and running events from a quarter mile to a mile. He was on the Oxford University Athletic Club team in the shot put and hammer throw, and also swam on the water polo team. During his vacations he traveled widely on the continent with college friends, mostly by train and bicycle. His trips included visits to France, Belgium, Switzerland, Germany, Austria-Hungary, and Spain, as well as several long tours of England. At the end of three years, the maximum allowed for a Rhodes Scholar, Hubble returned to the United States with the announced intention of practicing law.

During Hubble's senior year at the University of Chicago, his family had moved to Kentucky, where his father took over the National Fire Insurance Company agency in Louisville. At first they lived in nearby Shelbyville and he commuted to his office, but in 1911 they moved in to Louisville. John Hubble, however, suffered from a kidney disease, from which he died at the age of 52 on January 19, 1913, during Edwin's last year at Oxford. The family moved from South Brook Street to a smaller house on Everett Avenue, both located in a pleasant, tree-lined, middle-class

To

Edwin P. Hubble

Our beloved teacher of Spanish and Physics, who has been
A loyal friend to us in our senior year.
Ever willing to cheer and help us
Both in school and on
The field.
We
The class of 1914 lovingly dedicate this book

Edwin Hubble, when he was a teacher at New Albany High School, Indiana, 1914, reprinted from the dedication page of the yearbook, The Senior Blotter.

residential area. Edwin's older brother Henry began work for the Kentucky Actuarial Bureau, and later became an insurance agent himself.

Soon after Hubble returned home, he passed the Kentucky bar examination. At the time this was not a written examination; the process consisted of the candidate, traditionally bringing a bottle of Kentucky bourbon or a box of cigars as a gift, visiting a circuit court judge of a neighboring county, who would quiz him and then advise him in the duties of an attorney, often in his home over dinner. However, there is absolutely no record that Hubble ever actually practiced law in Kentucky. This is not surprising; the Oldham County judge in La Grange, a 22-mile interurban trolley ride from Louisville, would have been glad to do a favor for the grieving widow of an insurance agent he probably knew. It would be no problem to pass the handsome, attentive son who obviously was an expert in the general principles of jurisprudence after three years of Oxford, but had no knowledge whatever of the details of Kentucky laws or practice.

What Hubble did do was get a job teaching Spanish and physics in the high school at New Albany, Indiana, a suburb of Louisville just across the Ohio River. Probably he commuted daily by streetcar, though this is not certain. In addition to teaching, he coached the high school basketball team, taking them through an undefeated season and all the way to the state tournament in Bloomington, where they won their first two games before they were eliminated. Hubble was a very popular teacher and coach, and the students of the Class of 1914 "lovingly" dedicated their yearbook to him.

Hubble, however, had decided to go back to astronomy; he knew by then that the school-teaching life was not for him. As the end of the school year approached he wrote Moulton, his astronomy professor at the University of Chicago, to ask about coming back as a graduate student. Moulton immediately recommended him very strongly to Edwin B. Frost, the director of Yerkes Observatory, where the graduate work was actually given:

> Personally, [Hubble] is a man of the finest type. Physically he is a splendid specimen. In his work here, altogether, and especially in science, he showed exceptional ability. I feel sure you would find him just the sort of man you would wish to have.

Hubble sounded good to Frost, especially because he had experience with scientific instruments in the physics lab and as a surveyor in the North Woods during his summer vacations. Yerkes needed graduate students who were well qualified to work as assistants on the observing program with the observatory's impressive 40-inch refractor. Though the fellowships for the next year were already taken, Frost could offer Hubble a "service scholarship" covering tuition ($120 a year), plus $30 a month for his living expenses. The observatory was located in the little village of Williams Bay, on Lake Geneva in southern Wisconsin, about seventy miles northwest of Chicago. Hubble jumped at the offer, borrowed W.W. Campbell's Stellar Motions and Agnes Clerke's History of Astronomy in the Nineteenth Century from Frost, and wrote that he would come to Yerkes in the fall. However, the American Astronomical Society was going to meet at nearby Evanston, Illinois at the end of August, and its members would visit Yerkes for one day. Frost suggested that Hubble come north in time for the meeting, and said he would recommend him

Edwin Hubble (second from left in back row) with friends on an outing in the woods, Indiana, May 1914. Second from the left in the front row, holding a dogwood branch, is Rosbraugh Roberts, whom Hubble was courting, according to family tradition. (Photograph courtesy of John Hale)

The American Astronomical Society meeting, Northwestern University, Evanston, Illinois, August 1914. Edwin Hubble, in a dark suit, is second from the right in the front row; the three men near the center of the front row are the Society officers (left to right) Frank Schlesinger, Edward C. Pickering, and George C. Comstock. V. M. Slipher is second from the left, in the second row from the rear, wearing a wing collar. (Photograph courtesy of Dearborn Observatory, Northwestern University)

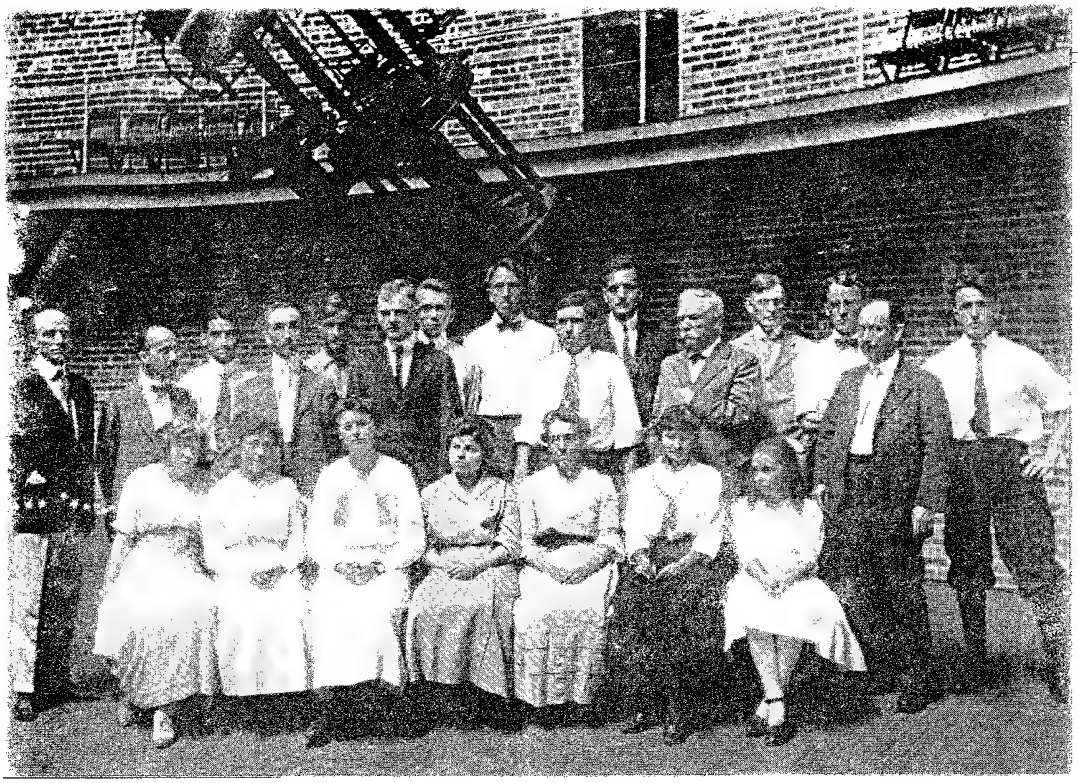
for membership if he wished. The dues were $2 a year, and Hubble quickly joined up.[1]

Therefore he was present at the meeting on the Northwestern University campus at which V.M. Slipher, the quiet, modest Lowell Observatory astronomer, presented his latest spectrographic observations of "nebulae" — a category that in those days also included what we today call galaxies. He had been the first to obtain well-exposed, well-calibrated spectrograms of spiral "nebulae" which not only showed their absorption-line spectra, but also revealed their large Doppler shifts and thus their large radial velocities (motions away from us). These are much larger than the typical velocities of stars, and when Slipher had presented his first results at Atlanta the previous summer, they had created a sensation. Some astronomers, including the renowned Henry Norris Russell, had expressed skepticism. Now, in the paper Hubble heard, Slipher had additional observational results, all of which confirmed and extended his earlier measurements. Hubble must have felt the excitement in the air.

In contrast, at Yerkes Observatory, Hubble found a near-moribund institution. Founded by George Ellery Hale and built around the largest refracting telescope in the world, it had gone into operation with great fanfare in 1897. But in 1904 Hale had left permanently for southern California, to build Mount Wilson Observatory, taking with him such astronomers as George W. Ritchey, Walter S. Adams, Ferdinand Ellerman, and Francis G. Pease. Frost, who inherited the Yerkes directorship, had originally been a competent spectroscopist, but without any creative ideas of his own he continued carrying on the same routine programs unchanged for years. He lost the sight of one eye while Hubble was at Yerkes, and stopped observing; he was to become completely blind in 1921, but nevertheless remained director until he retired in 1932. The senior faculty member, E.E. Barnard, had started his astronomical career as an amateur, and had made spectacular discoveries as a visual observer in his youth, and an outstanding series of wide-field photographs of the Milky Way later, but he had no theoretical training or ideas and did not advise or teach students. The other faculty members were astronomical lightweights: John A. Parkhurst and Storrs B. Barrett, who had been hired originally as Hale's assistants and had been left behind when he took the "first team" to Pasadena, and Oliver J. Lee, a longtime Yerkes computer (a person, not a machine, in those days) and assistant, who had just become an instructor.

Edwin Hubble (center) under an overhang in Wyandotte Cave, Indiana, 1914. John R. Roberts is at the left. (Photograph courtesy of John Hale)

1. Eight years later Hubble also joined the A.S.P. He served as the Society's President in 1933, and won the Bruce medal in 1938. He also wrote a number of popular A.S.P. *Leaflets*, starting with number 10 in March 1927 on "Exploring the Depths of Space." — *Ed.*



Yerkes Observatory group in the 40-inch telescope dome, September, 1916. Edwin Hubble, wearing a dark suit, is standing sixth from the right in the rear row. Just to the right of him, the white-haired man is E. E. Barnard, and the thinner man to the right of him, wearing a light gray coat, is Edwin B. Frost. Storrs Barrett is at the far left, and John Parkhurst is fourth from the left. (Photograph courtesy of Yerkes Observatory, Williams Bay, Wisconsin)

No formal courses were offered at Williams Bay; in each quarter of his two years there Hubble would merely register, with the few other students, for "Research at Yerkes Observatory." He observed regularly on the radial-velocity program with the 40-inch telescope, and except for some other minor duties the rest of the time was his own, for study and research under the general supervision of Frost. The 24-inch reflector, built by Ritchey, had been standing mostly idle since its maker had left for Mount Wilson. Somehow, perhaps inspired by Slipher's paper and encouraged by Frost, Hubble began a program of nebular photography with it. Soon he made his first discovery; comparing his direct plates of NGC 2261 with an earlier plate taken by Frank Jordan and with other plates from other observatories, he could see that definite changes had occurred within the nebula in a few years. It was an important result, not only because it demonstrated that changes can occur in nebulae, but also because it showed that this nebula must be small and relatively near. Two other variable nebulae were known, and Hubble noted that all three of these objects are associated with "dark occulting matter" (interstellar dust), an important step toward understanding them. Frost included these results in the paper he presented at the meeting of the National Academy of Sciences in Washington in April 1917.

Hubble's program grew into his Ph.D. thesis, "Photographic investigations of faint nebulae." It contains many foreshadowings of his later research on galaxies and the universe. He described and classified the numerous small, faint "nebulae," stated correctly that most of them are not spirals (as was then widely believed), but what we now call ellipticals. He confirmed and emphasized that their distribution in the sky avoids the Milky Way, and that many of them occur in clusters. "Suppose them to be extra-sidereal and perhaps we see clusters of galaxies; suppose them within our system, their nature becomes a mystery," he wrote. If the typical spiral "nebula" has the same size as our Milky Way system, he said, estimated by Arthur S. Eddington as 2,000 parsecs (or 6,500 light years) in radius, they must be at distances measured in millions of light years. Hubble's thesis is not very good technically, contains few references to earlier work, and is decidedly confused in its theoretical ideas, but it shows clearly the hand of a great scientist groping toward the solution of great problems. Hubble was never an outstanding technical observer, like Walter Baade and Milton L. Humason, but he always had the drive, energy, and enough skill to use available instruments so as to get the most out of them. He was aware of the 24-inch reflector's limitations, and of his own. But he recognized the right questions to ask, and he had the self-confidence to see what was on his plates, and describe it, whereas others who had perhaps seen it before had ignored it, or worse, tried to ignore it, because it did not fit the current pictures of the universe that they had in their minds.

Hubble was clearly a very good student and research worker, but in the context of the Yerkes Observatory of that time he was unique. A large fraction of its students were teachers at colleges who came only in the summers, typically only one student completed the Ph.D. every two or three years beginning in 1904, and, except for Hubble, none of them was ever heard of again before Otto Struve, who started in 1920 and finished in 1923.

For his second year Hubble received a fellowship which paid $320, and for his third year Frost recommended him for the top fellowship, worth $520, but there was not enough money and he got $320 again. Following the normal pattern, Hubble returned to the campus for the fall and winter quarters of that last year, to take the required graduate courses in mathematics, physics, and astronomy, the latter all celestial mechanics and "theories of applied differential equations" (numerical methods of integrating orbit equations), and to begin writing his thesis. He also became the graduate resident head of Snell Hall, one of the men's dormitories, a perfect post for a natural leader of his abilities, which gave him free room and board.

In October 1916 Hubble met Hale, the director of Mount Wilson Observatory, who often visited Chicago, where his brother lived and where he himself had been born and grown up. He had evidently heard through the astronomical grapevine of the bright young student doing an observational thesis on nebulae with the 24-inch reflector. Hale was looking for future staff members, for the 100-inch reflector was nearing completion on Mount Wilson.

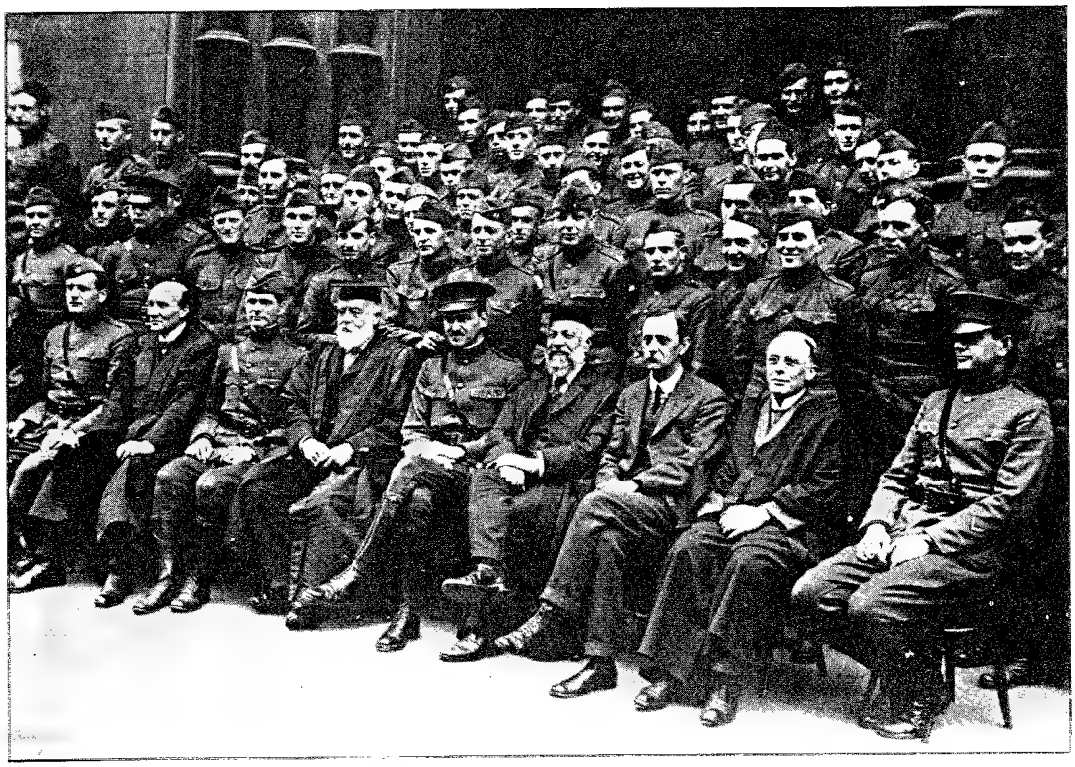
Henry Gale, Hale's friend and collaborator in the Chicago physics department, recommended Hubble highly, and when Hale met him he offered him a job, conditional on completion of his Ph.D.

Frost had planned that Hubble follow the normal program and return to Yerkes for his last quarter, to complete his thesis and take the final oral examination. However, by January 1917 the United States was close to entering World War I against Germany, a preparedness campaign gripped the nation, and patriotic young Americans, especially fomer Rhodes Scholars, were itching to get into the fight. Hubble, probably partly to keep closer to the center of the action and partly because he liked life on the campus better than in the isolated Williams Bay, decided to remain in Chicago for his last quarter. Moulton had offered him the chance to teach an elementary astronomy course and he took it. At the end of March, Hubble went out to Yerkes and obtained his last plate of the variable nebula. He still hoped to finish his thesis in June and take the job at Mount Wilson. But on April 4 President Woodrow Wilson went to Congress and asked for a declaration of war; on April 6 he got it and America was in the fight.

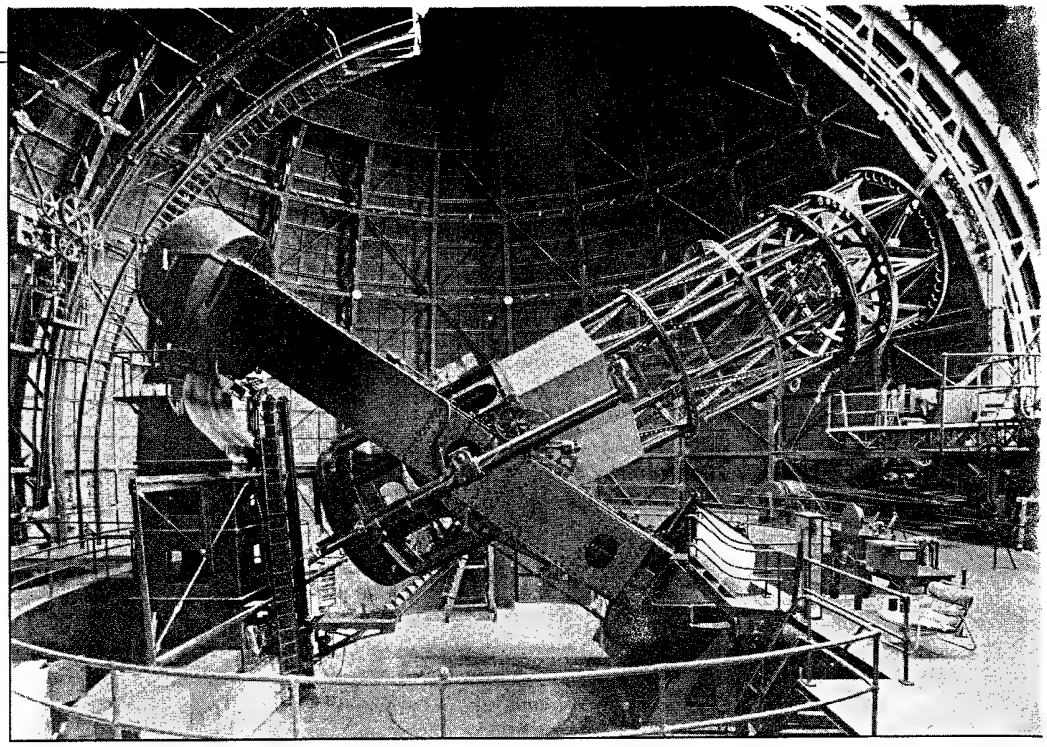
Four days later Hubble sent Frost a report on his work of the previous quarter, together with a second paper on NGC 2261, and asked him to recommend him for a commission in the army! Under the preparedness laws then in force, any college graduate like Hubble could apply for a commission, and needed only letters of recommendation from five worthy citizens to prove his qualifications. Frost of course obliged, but urged Hubble to complete his thesis and take his final examination before going off to war. Hubble also wrote Hale, telling him of the step he was taking, requesting a letter of recommendation, and asking him if he knew any reason he should not join the army. Hale, already deeply engaged in organizing the U.S. wartime scientific effort at the National Research Council in Washington, replied that "under the circumstances it would be natural for you to apply for a commission" and added that he "hope[d] to renew" his offer of a position at Mount Wilson as soon as Hubble had his degree and the war ended. He enclosed a letter recommending Hubble "as one most worthy of receiving a commission ... who will, I am sure, be a credit to the service."

By May 1 Hubble had learned that the officers' training camp to which he was to be sent would open in two weeks. He had completed the draft of his thesis and was brushing it up, but it still seemed "scrimpy" to him. Frost advised him to fatten it up by including his paper on NGC 2261 in it. In normal times he would probably have insisted that Hubble rewrite and expand the thesis, but under the circumstances that was impossible. On Saturday May 12 Hubble took his final oral examination at Yerkes, before Frost, Barnard, Parkhurst, MacMillan, and Lee, and passed with flying colors. The committee awarded him his degree magna cum laude. On Tuesday May 15 he reported for duty at nearby Fort Sheridan.

The "fort" was actually a military reservation on Lake Michigan, north of Evanston and Chicago, used as a training area in World War I (and later again in World War II). Hubble and the other college graduates who started officer training the same week he did made up Company 10, Illinois Training Camp. They took a quick one-month course in everything from signaling to bayonet fighting with plenty of close-order drill, and military courtesy and discipline as well, no doubt. Hubble thrived on it and reported to Frost, "this military game seems to be a nitch [niche] into which I fit. I was the fourth man to be made student captain — we have a new one each week ... " After one month most of the candidates were sent on to the artillery, in which they would become first or second lieutenants, but Hubble volunteered for the infantry, in which he could expect to be commissioned as a captain. At his commanding officer's request, he instructed his fellow trainees in night marching by the stars, using books borrowed from the Yerkes library. After two months more training in the 11th Provisional Regiment at Fort Sheridan, Hubble was commissioned a captain



U.S. Army student-soldiers at the University of Sheffield, England, 1919. Major Edwin Hubble is seated in the front row at the far left; Col. Langley, his immediate superior, is seated third from the left; next to him is Sir Oliver Lodge, Sheffield University. (Photograph courtesy of Henry E. Huntington Library and Art Gallery, San Marino, California)



The 100-inch telecope at Mount Wilson. (Photograph courtesy of the Carnegie Institution Observatories)

on 15 August 1917.

He was ordered almost immediately to Camp Grant, near Rockford, Illinois, about 80 miles west of Chicago. It had been a cornfield only two months before and there Hubble and the other newly commissioned officers from the 11th Provisional Regiment were to bring into existence the 86th Division. Its commanding general, the senior staff officers, and the regimental commanders and the sergeants came from the regular army, while the rest of the initial cadre were new reserve officers. Two weeks after the officers had arrived, the first "selects" (draftees) began pouring in. Most of the men came from northern Illinois, Wisconsin, and Minnesota, and the unit was called the Black Hawk Division for the Sauk Indian chief who had battled the Americans in the region a century before. Hubble became commanding officer of the 2nd Battalion, 343rd Infantry Regiment as the 86th Division was being organized, or very soon thereafter. He gloried in it, and wrote to Frank Aydelotte, a fellow Rhodes Scholar who later became president of Swarthmore College:

> They have given me a Battalion to work my will upon, and, we hope, to lead to the front. Stirring times — I can't picture myself missing the gathering, as it were, of the clans.

New men kept arriving as the training continued. In October a large draft was sent to Texas to fill vacancies in the 33rd division, the Illinois National Guard division, being readied for shipment to France. Hubble's 86th Division became in reality a training division, with new recruits continually streaming in, and half-trained veterans of a few months departing for other divisions headed for France. Throughout the bitter cold winter of 1917-18 Hubble trained his 2nd Battalion. With his large stature, athlete's body, perfect physical condition, outdoor experience, enthusiasm, intelligence, and leadership ability, he was undoubtedly an excellent commander, and the letter of commendation he received for his service "during the very trying days while we were training at Camp Grant" was surely well deserved. He was promoted to major in January 1918. Frost, who had decided Hubble's thesis was not suitable for publication in the Astrophysical Journal, but should go into the Publications of the Yerkes Observatory, sent him the proofs, but he evidently did not receive them, or ignored them until after the war had ended. His paper was finally published in 1920.

By June 1918 nearly 90,000 men had passed through the Black Hawk Division to other units. Finally it received its orders to move to Hoboken, the port of embarkation, in August. However, the officers and men soon learned that their division was to be broken up, and that they were to become replacements in the divisions already committed in France. Most of the battalion, company, and platoon commanders, including Hubble, were ordered from their units to the Advance School Detachment consisting of 140 officers and an approximately equal number of noncoms. They sailed out of New York harbor on September 9 on the *Walmar Castle*, across the Atlantic Ocean, around the north of Ireland, and up the Firth of Clyde to Glasgow, where Hubble debarked on September 19. He and the rest of the detachment went by troop train to Romsey, near Southampton, where they were reunited with the rest of the division, which had landed at Liverpool. In Romsey they were hit by a raging influenza epidemic, but most of them survived and were ferried across the English Channel in paddlewheel steamers to Le Havre by night. From there Hubble and his fellow officers split off to the advanced combat training schools that General John J. Pershing's American Expeditionary Force had set up in France. First Hubble was sent to the Third Corps officers' school in Clamecy, far behind the lines, 200 km southeast of Paris and 100 km west of Dijon. In the first week of October he went on to the advanced school at Langres, about 35 km southeast of Pershing's headquarters at Chaumont, and closer to the Alsace-Lorraine front. It is probable that Hubble was taken from Langres, with other officer trainees, to observe the fighting in the Meuse-Argonne offensive, for soon after he returned to the United States following the war, he wrote Frost "I barely got under fire," and this was the only occasion on which he could have done so.

From the training schools Hubble and the other officers were sent back to rejoin the 86th Division at its camps in the vicinity of Bordeaux. Most of the enlisted men had gone to other divisions as replacements, but a skeleton cadre had been retained in each company, battalion, and regiment of the Black Hawk Division.

When the officers returned, they believed that their division would be filled with fresh replacements, retrained, and sent to the front, but the Armistice ended the war before this happened. The 86th Division never got into combat, or even into the reserve lines. On November 12 it was broken up, and most of its officers and men became the nucleus of the unit which operated the embarkation center at Le Mans, devoted to preparing their comrades for the journey back to the States and demobilization. Other officers were sent to other commands and headquarters throughout the American Expeditionary Force.

Frost, who had been following Hubble's and other former Yerkes students' wartime experiences with pride and concern, wrote him immediately after the Armistice. He gave him the news from the observatory, enclosed a recent paper by Slipher from Lowell Observatory on Hubble's variable nebula, and also sent him a letter of introduction that would help him to visit observatories in Europe, now that the war was over. Hubble had many friends among the officers of the 86th Division, among whom several, particularly the West Pointers, had important staff jobs in commands throughout France and Germany. With his handsome good looks, stern military bearing, general legal background, and ability to speak French and German, he was a good prospect for them. By Christmas 1918 Hubble was at U.S. Army of Occupation headquarters in Trier, Germany. In January he was sent back to the Combat Officers Depot in Gondrecourt, France, and then to Paris to serve briefly with the American Peace Commission. After a month there, he went back to Gondrecourt, no doubt for further processing, and then on to England. He had managed to find out about an Army program for officers and men to study in British universities while awaiting shipment back to the United States, and to have himself assigned to it.

Edwin Hubble, Mount Wilson Observatory, circa 1920. (Photograph courtesy of the Observatories of the Carnegie Institution of Washington, Pasadena)

The Army had set up, in record time, a vast system of schools, ranging from post and divisional schools to the A.E.F. University at Beaune, on the Côte d'Or in France. In addition, arrangements were made for qualified students to attend French and British universities. Candidates could volunteer for these programs, and, if they were lucky or had the right connections, be accepted. In all about 6,000 American officers and enlisted men attended universities in France, and 2,000 more, universities in England, in the spring and early summer of 1919.

Hubble was one of the two hundred army students who arrived at Cambridge at the end of March. Probably about ten or twenty percent of them were officers, the rest enlisted men. Hubble stated in a letter that he was "in charge of American Army Students in a dozen British Universities," and while this could not have been true from the start (a picture of the group at Sheffield University shows a colonel nearer the middle of the front row, clearly outranking Hubble, who is at one end of the same row) it may have been correct by the time he wrote it in June. As a major, Hubble probably was the ranking officer in Cambridge. He wrote that he was "availing myself of the opportunity of studying the school of statistical analysis as expounded by [Professor Arthur S.] Eddington." By this Hubble probably meant that he was studying notes taken by a student at the Michelmas (fall) term, when Eddington had lectured on "Combination of Observations," or readings from his syllabus for that course. Eddington himself was gone for almost the entire Easter term, when Hubble was in Cambridge, on the famous solar eclipse expedition to Principe, West Africa to measure the gravitational deflection of light.[2]

Hubble made these statements in a letter to Hale in May 1919, whom he wrote to remind of his pre-war job offer, and to ask if it still held. He told Hale that he often enjoyed the hospitality of H.F. Newall, the wealthy English astronomer who entertained regally in his great house Madingley Rise, close to the Cambridge Observatory. Hubble need not have worried, for Hale, and Adams, who was by now his trusted lieutenant and the acting director during his frequent absences, had kept the promising prospective staff member in mind all during the war. Hale assured Hubble that he could have a staff position as soon as he could get out of the army, at a salary of $1,500 and the promise of "advancement as rapidly as your work and the funds at our disposal will warrant. Please come as soon as possible," he added, "as we expect to get the 100-inch telescope into commission very soon, and there should be abundant opportunity for work by the time you arrive."

Newall had Hubble proposed for membership in the Royal Astronomical Society at its regular monthly meeting in London on 9 May, 1919, "from personal knowledge." Probably Hubble attended the meeting himself and met many of the English astronomers present; certainly he was on travel status in England for nearly a week including that date. Slipher had been proposed by the Council as an "Associate," the equivalent of an honorary membership reserved for distinguished foreign scientists, at the previous meeting of the Society.

Two months later Hubble certainly attended the special meeting of the Society held to meet and honor the American astronomers passing through England on their way to the conference in Brussels, which led to the founding of the International

2. For more on this expedition, see the article "Testing Einstein's General Relativity During Eclipses" by J. Zirker in the Jul/Aug 1985 issue of *Mercury*. — *Ed.*

Astronomical Union. W.W. Campbell, director of Lick Observatory, headed the American delegation, which also included Adams, Frank Schlesinger, S.A. Mitchell, Charles St. John, Benjamin Boss, Joel Stebbins, and F.H. Seares. Many of them gave papers at the Royal Astronomical Society meeting. Afterward all of them, and Hubble, joined their hosts at the Royal Astronomical Society Club dinner. The Club, with its restricted, self-perpetuating membership, included all the leaders of British astronomy; many of them were present for this informal meeting with the leaders of American astronomy. The tall, handsome American major sat between astrophysicist Arthur Schuster and Frank Dyson, the Astronomer Royal, close to Campbell, who was at the end of the head table. Hubble must have discussed his future at Mount Wilson with Adams, St. John and Seares, all of whom were on its staff, but no record has survived.

A few weeks later Hubble was on his way to the port of embarkation at Brest. He sailed for America at the end of July and landed in New York on 10 August. While Hubble was still a student at Yerkes Observatory, his mother had moved with her family to Madison, Wisconsin, only about 70 miles from Williams Bay (and not much further from Fort Sheridan or Camp Grant). However, he did not go there, but straight to California, with only a one-day stop in Chicago. He was discharged at the Presidio in San Francisco on 20 August 1919, and went immediately to Pasadena to begin work. He summed up his military career to Frost in the words:

> I am still a major. I barely got under fire and altogather [sic] I am disappointed in the matter of the War. However, that Chapter is finished and another is opening.

Hubble had come to Mount Wilson at a good time. The 60-inch reflector had been in use since 1908, and the 100-inch, first assembled and pointed at the sky from Mount Wilson in 1917 but held up by the war, finally went into general use by the staff on 11 September 1919, just a few days after Hubble's arrival. From his Yerkes experience he knew how to use reflectors effectively, and he knew about nebulae and about problems that needed solving. He went right to work. Milton L. Humason, later an outstanding staff member and Hubble's collaborator in his studies of the distant universe, broke in the newly appointed astronomer on 25 October 1919, the first time he used the Mount Wilson telescopes. Years later, Humason's memories of Hubble's first observing at Mount Wilson were still clear:

> I received a vivid impression of the man that night that has remained with me over the years. He was photographing at the Newtonian focus of the 60-inch, standing while he did his guiding. His tall, vigorous figure, pipe in mouth, was clearly outlined against the sky. A brisk wind whipped his military trench coat around his body and occasionally blew sparks from his pipe into the darkness of the dome. "Seeing" that night was rated as extremely poor on our Mount Wilson scale, but when Hubble came back from developing his plate he was jubilant. "If this is a sample of poor seeing conditions," he said, "I shall always be able to get usable photographs with the Mount Wilson instruments." The confidence and enthusiasm which he showed on that night were typical of the way he approached all his problems. He was sure of himself — of what he wanted to do, and of how to do it.

Edwin Hubble, seated at his desk, Pasadena, circa 1925. (Photograph courtesy of the Observatories of the Carnegie Institution of Washington, Pasadena)

The proofs of Hubble's thesis finally caught up with him and he corrected them and returned them; soon afterward his paper appeared in the Publications of the Yerkes Observatory. For a year or two he corresponded politely with Frost, giving him news of Mount Wilson and expediting visits for astronomers who came west from the Wisconsin observatory. Soon he had completed his first Mount Wilson research program, a comprehensive study of diffuse galactic nebulae (those within our Galaxy). He published the results, separating reflection nebulae and emission nebulae physically, and showing how their nature and observed properties depended completely upon the type of stars within them, which are the sources of their luminosity. Already in these papers he indicated he was also studying deeply the nature of the "non-galactic nebulae." This name he stated, "does not mean that the latter class must be considered as 'outside' our galaxy, but that its members tend to avoid the galactic plane and concentrate in high galactic latitudes." Clearly he had not yet fully accepted the conclusions of Edward A. Fath, Roscoe F. Sanford, and Heber D. Curtis, who had provided observational evidence that these objects are "island universes" or galaxies outside our own, as Hubble himself was soon to confirm brilliantly.

On 26 February 1924 Hubble married Grace Burke Leib. She had been born in Iowa, the daughter of John P. Burke and his wife Luella. Her father, as a young man, had been the cashier and then manager of a small bank in Walnut, Iowa. When Grace was two years old the family moved to San Jose, California, where John Burke became the manager of a street railway company, then an attorney, and then manager of the Bank of San Jose. In 1906 when Grace was 17, they moved on to Los Angeles, where John Burke

Grace Hubble in 1931. (Photograph courtesy of Henry E. Huntington Library and Art Gallery, San Marino, California.)

was a very successful banker, a vice president and director of the First National Bank of Los Angeles.

After her family moved south, Grace Burke finished high school at Marlborough, a prestigious private school for girls in west Los Angeles. Then she went to Stanford University, from which she graduated in the class of 1912. She was a good student who was elected to the scholastic honor society, Phi Beta Kappa; she was also a member of Alpha Phi sorority and of the Senior Prom Committee. Just before Christmas after her graduation she married her Stanford classmate, Earl R. Leib, the son of Judge Samuel F. Leib, a prominent San Jose attorney. Earl Leib was a geologist who worked for the Southern Pacific Company, often in the field, assaying coal deposits and mines, and the couple lived with her parents in Los Angeles.

Hubble first met Grace Leib at Mount Wilson. Her husband's older sister, Elna, was the wife of Lick Observatory astronomer William H. Wright. They had gone on many camping trips and climbing expeditions in the Sierras together. In June 1920 Hale invited Wright to bring his ultraviolet spectrograph to Mount Wilson and observe with it on the 100-inch telescope, and when the Lick astronomer drove south his wife came with him. They stopped in Los Angeles and urged Grace to come with them to the mountain, and stay with her sister-in-law at the Kapteyn Cottage, the little wooden summer house where wives and friends could live, while the astronomers observed at night and slept by day in the male-only "Monastery." As they drove up to the observatory, Wright described for his wife and sister-in-law the new Mount Wilson astronomer who had such great promise, Hubble. One day the two women walked over to the laboratory building, where the astronomers worked in the afternoons, to borrow some books from the little library it contained. It was there that Grace first saw Hubble. As she remembered it years later, after his death:

> When I first saw him on Mt. Wilson that summer afternoon in 1920, he was standing at the laboratory window, looking at a plate of Orion. This should not have seemed unusual, an astronomer examining a plate against the light. But if the astronomer looked an Olympian, tall, strong and beautiful, with the shoulders of the Hermes of Praxiteles, and the benign serenity, it became unusual. There was a sense of power, channeled and directed in an adventure that had nothing to do with personal ambition and its anxieties and lack of peace. There was hard concentrated effort and yet detachment. The power was controlled.

Probably it is a very good description of what she thought she saw, although Hubble had certainly not photographed Orion the previous June night, for it was behind the Sun in the daytime sky. During the rest of Wright's observing run, they met frequently at the Kapteyn Cottage, and when they left the mountain, Hubble rode down to Pasadena with them.

One year after that electrifying meeting, Grace Leib's husband Earl died. Alone, he had gone down into the shaft of an isolated coal mine in Amador County without a mask, and had been overcome by an unexpected accumulation of gas. He fell to his death. The State Industrial Accident Commission, which investigated the accident, ruled that he had died as a result of asphyxiation.

After Leib's death, Grace and Hubble met again, according to her account, just after the total solar eclipse of 10 September 1923. Lick Observatory sent a party to Baja California, near Ensenada, headed by Wright. His wife accompanied him, and again he asked Grace to come along with them. She was not enthusiastic until Hubble urged her to do so (evidently they were seeing each other or writing before this); then she decided to go. He accompanied the Mount Wilson party, headed by Adams, which was located near San Diego. Both groups, and all the other American astronomers in the vicinity, most of whom were on Catalina Island, were clouded out at the time of the eclipse, but afterward Grace and Hubble met in San Diego. "On February 26, 1924 we were married," is her next statement; more than this we cannot know. They honeymooned at her family's private cottage near Pebble Beach in Carmel, then went abroad for a tour of Europe before he returned to his work at the observatory. During the trip to Europe, Hubble stopped off at a Royal Astronomical Society meeting in London on April 11, to give a talk on his work on the classification of nebulae, and afterward dined at the Club again.

By this time Hubble was making very rapid progress on understanding the nature of the spiral "nebulae." John C. Duncan, a frequent visitor to Mount Wilson Observatory from Wellesley College, had used the 60-inch and 100-inch telescopes to discover three variable stars in M33, one of the largest spiral "nebulae." Hubble quickly took over this program and found many more variable stars in M33, and in M31. From a long series of observations he was able to derive light curves of these variables and show that many of them are Cepheid variables. These stars, of a recognizable type known in our Galaxy, in addition to the novae that George W. Ritchey, H.D. Curtis, and Harlow Shapley had previously discovered in M31 and other spirals, convinced all but a handful of the most skeptical astronomers that these objects are actually galaxies of stars. Hubble's work soon became well

Edwin Hubble in a very dramatic pose, 1947. (Photograph courtesy of Henry E. Huntington Library and Art Gallery, San Marino, California)

Milton Humason, who became Hubble's close collaborator. (Photograph courtesy of the Carnegie Institution Observatories)

known, and he shared in a $1,000 prize for the outstanding paper read at the Washington meeting of the American Association for the Advancement of Science at the end of 1924. His paper listed 22 Cepheids in M33 and 12 in M31, and from them he derived the distances of these two spiral galaxies. A series of papers on NGC 6822, M33, and M31 quickly followed, along with Hubble's papers on the classification of galaxies and their absolute magnitudes. Before long Humason was working with him, measuring the radial velocities of galaxies for Hubble's discussions of the velocity-distance relationship. Hubble was soon established as the outstanding observational cosmologist, and he dominated the field until his death in 1953. ■

For Further Reading about the Life and Work of Edwin Hubble

1. General Historical Books with Sections on Hubble

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Hubble's Scientific Accomplishments

Allan Sandage
Carnegie Observatories

Dr. Allan Sandage is an Astronomer at The Observatories of the Carnegie Institution in Washington and one of the world's leading cosmologists. He was Edwin Hubble's research assistant and, among many other accomplishments, continued (and expanded) Hubble's work on the age, expansion, and deceleration of the Universe. He received the Bruce Medal, the A.S.P.'s highest honor, in 1975. These comments are excerpted with permission from an article entitled "Edwin Hubble", published in the December 1989 issue of the *Journal of the Royal Astronomical Society of Canada.*

Edwin Hubble's name is attached to many things in everyday astronomical life. There is Hubble's zone of avoidance, the Hubble galaxy type, the Hubble sequence, the Hubble luminosity law for reflection nebulae, the Hubble luminosity profile for E galaxies, the Hubble constant, the Hubble time, the Hubble radius for the universe, and now the Hubble Space Telescope. It seems appropriate in this centennial year to celebrate the memory of a scientist who some have called the greatest astronomer (in changing paradigms) since the times of Galileo, Kepler, and Newton. While Hubble's contributions spanned many fields of astronomical research, in this brief box we restrict ourselves to his major contributions to the study of the large-scale structure of the universe.

From 1922 to 1936 Hubble solved four of the central problems in cosmology, any one of which would have guaranteed him a position of the first rank in astronomical history:

- Between 1922 and 1926, Hubble proposed a classification scheme for the nebulae — a term that in those days included both the diffuse nebulae (clouds of gas and dust) in our own Galaxy *and* the extragalactic "nebulae" which we now call galaxies. His galaxy classification system is today known as the Hubble morphological sequence of galaxy types. Hubble's best discussion of it was in his popular-level book *The Realm of the Nebulae*, which has recently been re-issued by Yale University Press.
- With his discovery of Cepheid variable stars — which could be used as distance markers — in the galaxy NGC 6822 in 1924, as well as M31 (the Great Galaxy in Andromeda) and M33, Hubble settled decisively the question of the nature of the galaxies. Although the correct solution — that the galaxies were independent systems of stars — had, to be sure, been given by Curtis, Lundmark, and Öpik, their arguments were inconclusive for many of their colleagues at the time.
- With Hubble's final proof that the galaxies are beyond the confines of the Milky Way, the major problem then became whether they are fair markers of the universe, or if they are merely part of a hierarchical structure in a next rung up in the cosmic organization of matter. If they increase in numbers in proportion to the volume of space we survey (with no indication of an edge, as with the stars in our galaxy), they would then be basic units in the distribution of matter in the universe.

  Between 1926 and 1936 Hubble undertook a massive observing program using the enormous power of the 100-inch reflector at Mount Wilson to determine the distribution of the galaxies. He found them to be homogeneously distributed with distance when averages were taken over many sightlines, showing that they truly mark a space that is significant to the universe itself.

  Later, working with Richard Tolman, Hubble attempted to use counts of galaxies to measure the curvature of space predicted by the solutions of the equations of Einstein's General Theory of Relativity. While the attempt failed because of large photometric errors and what we now know to be the overwhelming effects of the evolution of galaxies over cosmic times, nevertheless the grandeur of the conception and the daring of the observational program still impresses the modern reader of their papers.
- Starting with his discovery paper in 1929, Hubble set out what is now called Hubble's Law of expansion — that the redshift in the spectrum of a galaxy is observed to be proportional to its distance. In collaboration with Milton Humason, Hubble between 1931 and 1936 verified and extended this relationship to greater and greater distances. This work led to the notion of the *expanding universe*, which is still the centerpiece of the modern cosmological models.

Acknowledgements

We are very grateful to many helpful friends, colleagues, and correspondents who provided information without which this study of Edwin Hubble's early life would have been incomplete: to John D. R. Bahng (Northwestern University), Diane Batson (Wheaton Central High School), Judith L. Bausch (Yerkes Observatory), Barbara Beury (New Albany Senior High School), Lawrence Blakeé (Pasadena), Robert C. Bless (University of Wisconsin), D.W. Dewhirst (Cambridge University), Richard Dreiser, (Yerkes Observatory), R.A. Fletcher (Rhodes Trust), John Hale (New Albany), Mark Harris (Louisville Free Public Library), the late Rufus C. Harrod (Shelbyville), John Lankford (University of Missouri), Anthony Misch (lick Observatory), Roxanne Nilan (Stanford University), Andrew and Carl Osterbrock (Cincinnati), Steven Padilla, (Mt. Wilson Observatories), Leon E. Panetta (U.S. Congress), Grote Reber (Tasmania), John H. Rhodehamel (Huntington Library), John J. Sloanaker (Carlisle Barracks), Joseph L. Spradley (Wheaton College), Maxine H. Sullivan and Jillian Warmund (University of Chicago) and Wendy A. Whitfield (West Point).

Publications

These publications are available from the publisher listed or may be ordered through a local bookstore.

From the Astronomical Society of the Pacific . . .

390 Ashton Avenue, San Francisco, CA 94112

A new catalog of data on 18,891,291 celestial objects, compiled for use with the Hubble Space Telescope, is now available on two CD-ROM disks. The disks, which must be read by a CD-ROM player attached to a personal computer, contain information on the location, brightness, and classification of over 15 million stars and 3 million nonstellar objects (mostly galaxies). Put together to help guide the pointing of the Space Telescope as it searches for known and new objects at and beyond the limits of ground-based telescopes, the mammoth catalog includes only objects too faint for the human eye to see. The package includes the two CD-ROM disks in a protective case, software to read and display the information on Macintosh computers, software to read (but not to display) the data on IBM and compatible computers, and an introductory reading list about the Space Telescope project. The package price is $52.95.

The award-winning television astronomy series "Cosmos," hosted by Dr. Carl Sagan, is now available in home videotape format from ASP. The series, which won the Peabody award and three Emmys, was the most watched science program in the history of public television, and introduced millions of viewers to the exploration of the universe. Available on seven 2-hour VHS format tapes, the series features crisp color taken from the original master tapes and digitally mastered hi-fi stereo sound. In addition to the original 13 episodes, the package from the Society includes a new interview with Dr. Sagan updating the series and a paperbound copy of the book *Cosmos*. The entire package is available from the Society for $198.

A pamphlet outlining the best books of the last decade for learning about astronomy is now available from the ASP. Entitled "A Basic Astronomy Library," the annotated list includes 120 outstanding introductory books for guiding the novice to a better understanding of the universe. Its sections include books on astronomy in general, the origin of the universe, the planets, astronomy as a hobby, the search for life elsewhere, astronomy on computers, learning the constellations, and many other topics. A selected list of worthwhile children's books is also included. To receive a copy send $3.00 to ASP.

New Books to be Noted

Turn Left at Orion by Guy Consolmagno and Dan M. Davis. New York, Cambridge University Press, 1989. (LC 88-28562; ISBN 0-521-34040-X) $22.95.

This attractive book is a guidebook for beginning amateur astronomers. The Moon, planets, and nearly a hundred deep sky objects visible in the northern hemisphere are shown as they appear in a small 50-75 mm (2-3") telescope. The book gives detailed instructions on how to find these and other objects in the night sky and what to look for when you have found them. A brief summary of the current state of astronomical knowledge about each object is also included.

This book is the first guidebook specifically designed for small telescopes. The instructions assume no previous knowledge of astronomy. People of all ages and backgrounds will enjoy this helpful book. It is like having a friendly astronomer at your elbow describing where to look and what you will see. Objects are located in terms of easily visible nearby stars, rather than the more complicated celestial coordinates. Large format drawings show exactly what the observer should expect to see.

If you have a telescope that you tried once or twice and then gave up, you may want to try again with the help of this book. There are several tables of the objects, a glossary, and an index.

Physics and Astrophysics from a Lunar Base: First NASA Workshop, Stanford, CA 1989. Editors: A.E. Potter and T.L. Wilson. (AIP Conference Proceedings 202) New York, American Institute of Physics, 1990. (LC 90-55073; ISBN 0-88318-646-2) $60.00.

The concept for this workshop was to explore fundamental physics at a lunar base. It focused not only upon traditional space physics but also upon those other fundamental physics experiments that uniquely require the Moon in order to be performed. The possibility of a permanent human or man-tended presence at a mature lunar base implies several new concepts to such topics as a fundamental and high-energy physics facility; particle astronomy and particle astrophysics testbed; cosmic ray and cosmic abundance observatory; new vistas in neutrino/antineutrino astronomy; and a Moon-tethered space physics observatory.

This book will be of interest to those scientists who are looking toward the future of space physics and what can be done.

LPI Publishes First Technical Reports of 1990

Two technical reports have been published in the first quarter of 1990 by the LPI.

Workshop on Differences Between Antarctic and Non-Antarctic Meteorites, edited by Christian Koeberl and William A. Cassidy, is the report of the workshop held at Vienna, Austria, July 27-28, 1989. The workshop was structured to contain sessions on chemical, isotopic,